

JPRS-UES-84-007

10 December 1984

# USSR Report

EARTH SCIENCES

**FBIS**

FOREIGN BROADCAST INFORMATION SERVICE

## NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

## PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

Soviet books and journal articles displaying a copyright notice are reproduced and sold by NTIS with permission of the copyright agency of the Soviet Union. Permission for further reproduction must be obtained from copyright owner.

10 December 1984

## USSR REPORT EARTH SCIENCES

### CONTENTS

#### METEOROLOGY

Paleoclimatologists Use Past To Predict Weather Patterns (V. A. Zubakov, Interview; NEDELYA, No 19, 2-13 May 84)...	1
Thermodynamic Model Permits Calculation of Hurricane Force (SOTSIALISTICHESKAYA INDUSTRIYA, 11 Sep 84).....	3
International Conference on Physics of Clouds (KAZAKHSTANSKAYA PRAVDA, 29 Aug 84).....	4
Macrosynoptic Characteristics of Extremely Cold and Extremely Warm Decembers in Eastern Caucasus and Caspian Areas (S. N. Mamedova; IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR, SERIYA NAUKI O ZEMLE, No 3, 1984).....	5
Macrosynoptic Characteristics of Extremely Cold and Extremely Warm February Months in Eastern Caucasus and Caspian Areas (G. A. Aliyeva; IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR, SERIYA NAUKI O ZEMLE, No 3, 1984).....	5
Structure of Temperature Field Based on Observations of Refraction From High Meteorological Mast (S. P. Beschastnov, G. M. Grechko, et al.; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	6
Influence of Mountain Relief on Distribution of Heat and Moisture (E. Sh. Elizbarashvili; IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA, No 2, Mar-Apr 84).....	7

# OCEANOGRAPHY

Manganese in Recent Sediments of Ukrainian SSR Black Sea Shelf (V. I. Ogorodnikov, K. S. Krasovskiy; DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA B: GEOLOGICHESKIYE, KHIMICHESKIYE I BIOLOGICHESKIYE NAUKI, No 6, Jun 84).....	8
Internal Waves in Ocean (A. D. Yampol'skiy, G. Ye. Kononkova, et al.; ZEMLYA I VSELENNAYA, No 4, Jul-Aug 84).....	13
Thirty-Seventh Cruise of 'Akademik Kurchatov' (V. I. Voytov; ZEMLYA I VSELENNAYA, No 4, Jul-Aug 84)....	21
'Unsinkability' of Ferromanganese Nodules (PRIRODA, No 3, Mar 84).....	28
Research Ship 'Vityaz' Completes Atlantic-Mediterranean Cruise (A. Androshin; PRAVDA, 2 Oct 84).....	30
Offshore Drilling and Research Vessle 'Poligon' (V. Kurapin; SOTSIALISTICHESKAYA INDUSTRIYA, 25 Sep 84)..	31
Research Ship 'Akademik Shuleykin' Completes North Atlantic Cruise (A. Kozlovskiy; LENINGRADSKAYA PRAVDA, 26 Sep 84).....	32
Observatory's Research Ships Cruise Baltic and North Seas (V. Butkus; SOVETSKAYA LITVA, 5 Aug 84).....	33
Research Ship '17th Trade-Union Congress' Completes Pacific Cruise (A. Isayev; TRUD, 20 Jul 84).....	34
Report on Non-Magnetic Vessel's Mediterranean-Atlantic Cruise (S. Nikonov; LENINGRADSKAYA PRAVDA, 24 Aug 84).....	35
Studies of Atlantic Submarine Mountains With Submersible Craft (A. Androshin; PRAVDA, 15 Sep 84).....	36
New Research Ship 'Petrov' Assigned to Geochemistry Institute (L. Khitrov; IZVESTIYA, 24 Sep 84).....	37
Bering Sea Cruise Plans of Research Ship 'Vulkanolog' (TRUD, 5 Aug 84).....	38
Divers Work from Bell at 200 Meters in Atlantic (A. Androshin; PRAVDA, 27 Sep 84).....	39
Cryogenics Applications for MHD Propulsion, Other Ship Technology (B. I. Al'shin Interview; VODNIY TRANSPORT, 18 Aug 84)...	41



Shipboard and Satellite-Aided Communications Equipment in Exhibition (V. Ryndin; SOVETSKAYA LATVIYA, 19 Jul 84).....	42
Status of Tsunami Forecasting Assessed on Opening of Conference (A. Zabolin; KOMSOMOL'SKAYA PRAVDA, 18 Sep 84).....	43
Caribbean and Mediterranean Operations of Manned Submersible 'Argus' (A. Androshin; PRAVDA, 26 Aug 84).....	44
Effect of Intensification of Decimeter Wind Waves in Petroleum Slick Zone (D. M. Bravo-Zhitovskiy, L. S. Dolin, et al.; DOKLADY AKADEMII NAUK SSSR, No 5, Jun 84).....	45
Possibility of Electromagnetic Diagnosis of Eddies in Open Ocean (M. M. Karnaushenko, A. I. Zhilina; VESTNIK AKADEMII NAUK UKRAINSKOY SSR, No 1, Jan 84).....	46
Effect of Sea Breeze on Thermal Structure of Littoral Waters (N. K. Shelkovnikov, V. V. Timofeyev; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	46
Influence of Electrostratification of Sea on Drift and Barogradient Current Electromagnetic Fields (G. A. Fonarev, V. V. Fidelis, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	47
Geomorphological and Lithodynamic Criteria for Search for Accumulations of Heavy Minerals on Shelf (M. N. Grigor'yev, Ye. I. Iganatov; VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA, No 3, May-Jun 84).....	48
Mean Entropy Flow Through Ocean Surface (T. R. Kil'matov; DOKLADY AKADEMII NAUK SSSR, No 5, Apr 84).....	48
Energy Active Areas of Ocean (S. S. Lappo, S. K. Gulev, et al.; DOKLADY AKADEMII NAUK SSSR, No 4, Apr 84).....	49
Some Methodological Aspects of Study of Layer Associations in Continents and Oceans (G. L. Kirillova, TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	49

Role of Bacterioplankton in Production and Cycling of Organic Matter in Southeast Pacific (Yu. I. Sorokin, T. I. Mamayeva; DOKLADY AKADEMII NAUK SSSR, No 6, Apr 84).....	50
Results of Geochemical Study of Bay Separated From Sea in Relation to Present-Day Kara-Bogaz-Gol Problem (L. A. Gavrilova; IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKOTEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK, No 1, 1984).....	51
Formation of Deep Eastern Mediterranean Waters in Adriatic (I. M. Ovchinnikov, V. I. Zats, et al.; DOKLADY AKADEMII NAUK SSSR, No 3, Mar 84).....	51
Caspian Sea Wave Fields With Moderate Wind Speeds in Prevailing Directions (M. I. Abakarov, A. N. Badalova, et al.; IZVESTIYA AKADEMII NAUK AZERBAJDZHANSKOY SSR: SERIYA NAUKI O ZEMLE, No 3, 1984).....	52
Dislocations and Cryolithogenesis in Pleistocene in Northern Eurasia (A. I. Popov; VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA, No 3, May-Jun 84).....	52
TERRESTRIAL GEOPHYSICS	
Earthquakes and Tectonics of Pacific Ocean Margins (L. M. Balakina; PRIRODA, No 3, Mar 84).....	53
Some Trends in the Modern Earth Sciences (V. V. Belousov; PRIRODA, No 6, Jun 84).....	63
Thermal Energy Resources of Thermal Waters in Kazakhstan (V. S. Zhevago, Zh. S. Sydykov; VESTNIK AKADEMII NAUK KAZAKHSKOY SSR, No 6, Jun 84).....	84
Two Super-Deep Boreholes Prove Valuable to Science, Nine More are Planned (Domestic Service, 15 Jun 84).....	91
Socialist-Bloc Conference on Geophysical Data Processing for Oil Prospecting (BAKINSKIY RABOCHIY, 29 Sep 84).....	92
Krivoy Rog Superdeep Borehole Targeted at 12 km (S. Chudakov; PRAVDA, 25 Sep 84).....	93
4,000-Meter Borehole Sunk for Geothermal Power Station (A. Kuz'ma; PRAVDA UKRAINY, 15 Aug 84).....	94
State Prize Nomination for Work on Rare-Earth and Uranium Magnetism (S. Vonsovskiy, Yu. Osip'yan; PRAVDA, 19 Sep 84).....	95

Statistical Relationship of Strong Earthquakes With Planetary Geomagnetic Field Activity (M. M. Pogrebnikov, N. I. Komarovskii, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	97
Faults on Sakhalin (V. V. Kharakhinov, Bezyuk Gal'tsev, et al.; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	97
Anomalous Magnetic Field in Northeastern Pacific Ocean and Pacific Ocean Plate Kinematics (A. M. Gorodnitskiy; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	98
Boundary Velocities of Mohorovicic Discontinuity and Upper Mantle Structure of Pacific Ocean Bed (N. Ya. Kunin, G. I. Semenova; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	99
Deep Structure of Terrestrial Crust and Upper Mantle in Southeastern Siberia and Far East According to Geological- Geophysical Data (L. Ye. Shustova; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	99
Correlation Radius of Gravitational and Magnetic Anomalies and Methods of Its Determination (S. A. Serkerov; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	100
Selection of Spacing of Modular and Gradient Measurement Surveys Based on Statistical Characteristics of Measured Geomagnetic Field (V. G. Boyarskikh, I. G. Zolotov, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	100
Asymptote of Solution of Petchek Problem of Rejoining of Magnetized Lines of Force (V. S. Semenov, I. V. Kubyshkin, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	101
Spectrum of Geomagnetic Field Variations in the Range of Periods Between 1 and 10 Years (Yu. R. Rivin; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	101
Energetic Parameters of Magnetotelluric Field Over Conducting Cylinder (E-Polarization) (Yu. B. Shaub; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	102

Possibility of Direct Accounting of Anomalies in Variable Geomagnetic Field During Aeromagnetic Surveys (M. N. Berdichevskiy, S. G. Sedov; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	102
Gravitational Models of Sikhote-Alin Folded Area (L. I. Bryanskiy; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	103
Conductivity of Sedimentary Mass on Sakhalin Island (I. M. Al'perovich, V. M. Nikoforov; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	103
Propagation of Nonlinear Seismic Waves in Media With Elasticity, Viscosity and Plasticity (V. I. Kondaurov, L. V. Nikitin; DOKLADY AKADEMII NAUK SSSR, No 4, Apr 84).....	104
Keyboard Model of Strong Earthquakes in Island Chains and Active Continental Fringes (L. I. Lobkovskiy, B. V. Baranov; DOKLADY AKADEMII NAUK SSSR, No 4, Apr 84).....	104
Estimate of Activity of Elbrus Volcano (N. I. Khitarov, Yu. K. Shchukin, et al.; DOKLADY AKADEMII NAUK SSSR, No 4, Apr 84).....	105
Geomagnetic Study of Ampere Seamount (A. M. Gorodnitskiy, Ye. A. Nazarova; BYULLETEN' MOSKOVSKOGO OBSHCHESTVA ISPYTATELEY PRIRODY: OTDEL GEOLOGICHESKIY, No 3, May-Jun 84).....	105
Influence of Demagnetization of Magnetic Anomalies of Intrusive Objects (Yu. I. Blokh; IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA, No 3, Mar 84).....	106
Kopetadag Upthrust Zone as New Object of Search and Prospecting Operations for Oil and Gas (Ya. A. Khodzhakuliyev, O. M. Panasenko, et al.; IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO- TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK, No 1, 1984).....	106
Structure of Sedimentary-Volcanogenic Cover of Eastern Kamchatka Based on Magnetotelluric Sounding Data (Yu. F. Moroz; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	107



Seismicity of Kuril Island System in Relation to Isostatic Crust Status (K. F. Sergeyev, Kim Chun Un, et al.; TIKHOOKEANSKAYA GEOLOGIYA, No 2, Mar-Apr 84).....	107
24-Year Variations in Geomagnetic Field and Corresponding Variations in Seismicity and Volcanism (Yu. D. Kalinin, T. S. Rozanova; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	108
Manifestations of Basaltoid Volcanism in Intracontinental Tectonic Structures (Yu. S. Genshaft, A. Ya. Saltykovskiy; DOKLADY AKADEMII NAUK SSSR, No 3, Mar 84).....	108
Influence of Cyclical Load and Long-Term Pressure on Magnetic Parameters of Basalt in Garni Geodynamic Testing Area, Armenian SSR (G. M. Avchyan, V. V. Nagapteya; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: NAUKI O ZEMLE, No 1, Jan-Feb 84)...	109
Long-Term Mean Seismicity Characteristics of Armenian SSR and Adjacent Regions (Based on 1962-1980 Data) (S. N. Nazaretyan, S. R. Aslanyan, et al.; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: NAUKI O ZEMLE, No 1, Jan-Feb 84).....	110
Joint Use of Long-Term Seismic Precursors for Caucasus (P. V. Aptsiauri, A. G. Chakhmakhchyan; IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: ANUKI O ZEMLE, No 1, Jan-Feb 84).....	110
Specifics of Earth's Thermal Conditions Beneath Focal Area of Tashkent Earthquake (Yu. N. Zuyev, V. I. Ulomov; UZBEKSKIY GEOLOGICHESKIY ZHURNAL, No 2, Mar-Apr 84).....	111
Relationship Between Variations in $\rho_{eff}$ and Electromagnetic Filtration Field in Tamdy Region (I. M. Makhkamdzhanov, R. I. Sultanbekov; UZBEKSKIY GEOLOGICHESKIY ZHURNAL, No 2, Mar-Apr 84).....	111
Internal Structure of Areas of Intensive Development of Volcanogenic Rock in Northwestern Portion of Bukantau Mountains (Western Uzbekistan) (V. M. Kheyfets, I. A. Fuzaylov; UZBEKSKIY GEOLOGICHESKIY ZHURNAL, No 2, Mar-Apr 84).....	112



Manifestations of Gamma Field in Certain Areas of Seismically Active Middle Tien Shan Fractures (D. Kh. Yakubov, A. R. Yarmukhamedov, et al.; UZBEKSKIY GEOLOGICHESKIY ZHURNAL, No 2, Mar-Apr 84).....	113
Results of Soviet-French Studies on Identification of High Seismicity Zones in Western Alps (A. D. Gvishiani, Kh. Sallanten, et al.; DOKLADY AKADEMII NAUK SSSR, No 6, Apr 84).....	113
Study of Kumdag Earthquake of 14 March 1983 (Dzh. Garagozov, G. L. Golinskiy, et al.; IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO- TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK, No 1, 1984).....	114
Features of Distribution of Radioelements in Dzhezkazgan Deposit (L. A. Trofimova, M. K. Satpayeva, et al.; IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA GEOLOGICHESKAYA, No 3, May-Jun 84).....	114
Geoelectric Section of Earth's Crust and Upper Mantle Along Chardara-Bayzhansay Profile (D. A. Al'mukhanbetov, S. Zh. Azhibayev, et al.; IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA GEOLOGICHESKAYA, No 3, May-Jun 84).....	115
Geological Effectiveness of Automated Processing of Highly Precise Aeromagnetic Surveys in Caspian Region (V. A. Boronayev, L. A. Koval', et al.; IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA GEOLOGICHESKAYA, No 3, May-Jun 84).....	116
Magnetotelluric Sounding Curves for Five-Layer Model With Surface Elliptical Inclusion (L. P. Mikhlin; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, No 3, 1984).....	116
Stresses and Strains in Lithosphere Caused by Earth's Thermoconvective Oscillations (B. I. Birger, S. M. Kovtunenkov; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, No 3, Mar 84).....	117
Fracturing of Medium and Its Relationship to Seismic Regime (I. D. Tsibul'chik; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, No 3, Mar 84).....	118
Singularities Method Applicable to Interpretation of Seismic Data (G. M. Voskoboynikov, A. F. Shestakov; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, No 3, Mar 84).....	119

Nonuniformity of Gravity Field in Rooms and Choice of Site for Conducting Gravity Experiments (M. U. Sagitov; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, No 3, Mar 84).....	120
Geothermal Field of Fault (S. S. Sardarov, Ye. V. Savina; DOKLADY AKADEMII NAUK SSSR, No 5, Jun 84).....	120
Use of Perminvar Effect in Thermally Magnetized Rocks in Determining Paleointensity (V. S. Vechfinskiy, Yu. K. Vinogradov, et al.; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, No 3, Mar 84).....	121
Studying Orientation of Ordered System of Fractures by Seismic Polarization Method (V. A. Yakubov; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI, No 3, Mar 84).....	122
Titanomagnetites of Magmatic Rocks in Komandorskiye Islands as Indicators of Geodynamic Regime (Yu. S. Genshaft, D. M. Pecherskiy, et al.; IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOLOGICHESKAYA, No 4, Apr 84).....	123
Geohydrodynamics of Promising Petroleum- and Gas-Bearing Complexes in Tunguska Basin (M. B. Bukaty; GEOLOGIYA NEFTI I GAZA, No 2, Feb 84).....	124
Tectonics and Presence of Petroleum and Gas in Northern Crimean Downwarp (V. G. Bondarenko; GEOLOGIYA NEFTI I GAZA, No 2, Feb 84).....	125
PHYSICS OF ATMOSPHERE	
Chemical Kinetics and Earth's Atmosphere (V. L. Tal'roze; VESTNIK AKADEMII NAUK SSSR, No 3, Mar 84).....	126
Processes of Smooth Increase and Dropoff in Intensity of Glow Line $\lambda' = 5577$ A With Exposure of Ionosphere to Electron Beam (T. G. Adeyshvili, G. G. Managadze; SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR, No 1, Jul 83).....	127
Investigating Phase Structure of Electromagnetic Field in Local Inhomogeneities by Modeling Method (A. N. Bukin, A. E. Isayev, et al.; VESTNIK LENINGRADSKOGO UNIVERSITETA: FIZIKA, KHIMIYA, No 4, Feb 84).....	127

Observation of Natural Noise Near Upper Hybrid Resonance in Terrestrial Magnetosphere by Prognoz-5 Satellite (G. M. Artem'yeva, V. P. Grigor'yeva, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	128
Distribution of Electric Field Near Westward Propagating Bend in Aurora (V. G. Petrov, T. V. Kozelova, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	129
Longitudinal Current Before Westward Propagating Auroral Bend (T. V. Kozelova, V. B. Lyatskiy; GEOMAGNETIZM I AERONOMY AERONOMIYA, No 2, Mar-Apr 84).....	129
Ionospheric Effects of Surface Industrial Shots (I. I. Varshavskiy, A. D. Kalikhman; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	130
Relationship Between Doppler Frequency Shift Spectra and Perturbations Moving in Ionosphere (M. B. Vinogradova, V. D. Gusev; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	131
Statistical Interrelationship of Maximum Frequency and Screening Frequency of Middle Latitude E <sub>s</sub> Layer (S. A. Okhremchik, T. A. Radchenko; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	131
Stationary Ionospheric Disturbances Based on Intercosmos-19 Data (V. V. Vodyannikov, Yu. K. Postoyev, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	132
Nature of Short-Period Variations of Cosmic Rays in Stratosphere (Yu. I. Barannikov, O. A. Barsukov, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	132
Determination of Volumetric Coefficient of True Light Absorption by Aerosol Based on Aircraft Measurement of Spectral Flux in Cloudless Atmosphere (L. A. Gavrilova; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	133
Numerical Modeling of Random Processes and Fields Based on Palm Point Fluxes in Problems of Radiation Transfer in Clouds (V. S. Troynikov; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	133

Mechanism of Damping of Plasma Oscillations in Initial Stage of Injection of Electron Beams From Spacecraft Into Ionosphere in Active Experiments (V. A. Fedorov; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	134
Simple Formula To Estimate Carbon Dioxide Gas Effect in Radiation Balance of Underlying Surface (Zh. K. Zolotova, K. S. Shifrin; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	134
Solar Wind Dynamics at Small Distances From the Sun (N. A. Lotova, D. F. Blums; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	135
Dynamic Amplitude, Phase and Polarization Spectra of Combination Frequency Signals (A. M. Babichenko, S. A. Gusev, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	135
Possible Effects of Interaction of Electric Seismic Fields With the Ionosphere (M. B. Gokhberg, N. I. Gershenzon, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	136
Lidar Measurements of Structural Characteristics of Atmospheric Turbulence (M. S. Belen'kiy, A. A. Makarov, et al.; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	137
Diurnal Variation Harmonics and Spatial Change in Cosmic Ray Flux (Yu. P. Mel'nikov; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	137
Electric Field in Plasma Layer of Magnetosphere During Preliminary Substorm Phase (V. A. Sergeyev; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	138
Fine Structure of Alfvén Maser Radiation (P. P. Belyayev, S. V. Polyakov, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	138
Additional Possibilities of Methods of Partial Reflections Using a High Power Installation (S. I. Martynenko, L. F. Chernogor; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	139

Repulsive Force of 'Magnetic Clouds' During Solar Flares and Magnetospheric Substorms (K. G. Ivanov, A. F. Kharshiladze; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	139
Limits of Applicability of Long Wave Theory on Studies of Oscillations of n-Layer Fluid (M. V. Babiy; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	140
Characteristic Scale of Inner Mixing Layers in Stably Stratified Atmosphere (M. V. Kurganskiy; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	140
Internal Gravity Waves in Real Atmosphere (O. V. Kaydalov, T. V. Solov'yeva; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	141
Influence of Refraction Effects on Informativeness of Bistatic Acoustical Atmospheric Sounding Systems (A. Ya. Bogushevich, N. P. Krasnenko; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	141
Long-Distance Propagation of Infrasound in Atmosphere Near Earth's Surface (G. A. Bush, A. I. Grachev, et al.; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	142
Study of Low-Frequency Sound With Point Source in Stream With Shear (V. P. Goncharov; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	142
Analysis of Ionization Sources in D Region Based on Theoretical Models (M. N. Vlasov, V. V. Medvedev; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	143
Medium- and Large-Scale Wave Disturbances and Heterogeneities of Electron Concentration in Outer Ionosphere in Middle and Low Latitudes (M. N. Fatkullin, G. K. Solodovnikov, et al.; GEOMAGNETIZM I AERONOMIYA, No 2, Mar-Apr 84).....	143
Modeling Influence of Three Layer Cloud Cover on Outgoing Thermal Radiation (I. M. Gracheva, I. I. Mokhov, et al.; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	144



Actual Altitudes of Radioacoustic Sounding in Decimeter Wavelength Band (V. D. Belyavskaya, M. A. Kallistratova, et al.; IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA, No 4, Apr 84).....	145
---	-----

#### ARCTIC AND ANTARCTIC RESEARCH

Station on Lednik Vavilov Conducts Research (N. Osipov; LENINGRADSKAYA PRAVDA, 19 Aug 84).....	146
Development of Radar To Measure Sea Ice Merits Prize Nomination (Yu. Kobzarev; IZVESTIYA, 1 Sep 84).....	147
Cargo Vessels for Shipping to Arctic Points Without Port Facilities (A. Yaitskiy; RABOCHAYA GAZETA, 12 Sep 84).....	148
Scientists From Many Nations Conduct Antarctic Research (V. Bardin; PRAVDA, 17 Aug 84).....	149
Weddell Polynia as Result of Hydrophysical Processes in Weddell Circulation (N. V. Bagryantsev, E. I. Sarukhanyan; DOKLADY AKADEMII NAUK SSSR, No 5, Jun 84).....	150
History and Prognosis of Changes in Antarctic Ice Cover (S. M. Myagkov; VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA, No 3, May-Jun 84).....	151
Specifics of Evolution of Cyclonic Ring in Antarctica (Yu. A. Ivanov, A. Yu. Krasnopevtsev, et al.; DOKLADY AKADEMII NAUK SSSR, No 4, Apr 84).....	151

## METEOROLOGY

### PALEOCLIMATOLOGISTS USE PAST TO PREDICT WEATHER PATTERNS

Moscow NEDELYA in Russian No 19, 7-13 May 84, p 15

[Interview with V.A. Zubakov, Senior Science Associate of the State Hydrologic Institute, by Alexander Viktorov in Leningrad; no date given]

[Excerpt] [Question] What problems are currently of particular concern to paleoclimatologists?

[Answer] From the theoretical point of view, special interest is evoked by the study of the fundamental differences in two types of global climate that have repeatedly alternated in geological history--the glacial and the greenhouse climates. The data that we have received are unusually interesting.

For example, in the "greenhouse" times at the high latitudes, there arose climatic conditions with a warm polar night, something that is quite foreign to our imagination. Apparently, the temperature did not fall below 12 to 15 degrees Celsius. Obviously, the organic world of that time was adapted to this. Right up to a latitude of 77 degrees north in the arctic, geologists are finding remains of plants and animals that are now associated only with the tropical zone, including palm trees and crocodiles! It is quite possible that the plants that were then growing in the arctic and antarctic dropped their leaves prior to the arrival of the polar night, and the animals went into hibernation.

Another direction in the research is a detailed study of the climatic history for the last 20,000 years. New data are leading to the conclusion that the destruction of the ice of the last glaciation began 16,000 years ago, that is, 6,000 years earlier than was thought until recently. The reason for this was the increase in solar radiation. A detailed clarification of the climatic history for the past 16,000 years also indicates that between the 13th and 4th millennia under a general warming trend, when the average temperature of the earth reached the present level and even exceeded it by 1 to 1.5 degrees Celsius, there was a series of short--lasting 100 to 140 years--but very sharp periods of cooling. The evidence for this is not only geological and isotopic but also historical.

The reasons for these dramatic periods of cooling, which have been designated climatic crises, are still unclear. One of the hypotheses links them to intense volcanic blasts that lowered the transparency of the atmosphere. But the period

of cooling lasted for hundreds of years, whereas the volcanic aerosol remains in the atmosphere no longer than 3 to 7 years and lowers the temperature by only 0.5 to 1 degree. The second hypothesis relates the climatic crises, which recur approximately every 500-600, 1,000-1,200 and 2,400-2,700 years, to the rhythms of the geomagnetic field and the gravitational influences of the planet. According to the third hypothesis, this abrupt cooling comes about as a result of "sërdzhi," a catastrophically rapid casting off of large masses of glacial ice into the ocean, where they form huge fields of icebergs that drift toward the equator. The resulting inevitable fall in temperatures must indeed be catastrophically abrupt and last until the icebergs melt.

Thus, the increase in the concentration of carbon dioxide in the atmosphere can produce not only a rapid warming of the climate but also an abrupt change to a colder climate. In any case, the paleoclimatic data do not rule out such a "scenario." Specialists have no doubts about a future warming of the climate in the 21st century. In regard to colder periods, they will become a reality if the "sërdzhi" hypothesis for climatic crises is confirmed. And since such an equivocal forecast for the evolution of the climate promises some very unpleasant situations for mankind, the research in the area of predictive paleoclimatology is now becoming especially topical.

9746  
CSO: 1865/58

# THERMODYNAMIC MODEL PERMITS CALCULATION OF HURRICANE FORCE

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 11 Sep 84 p 3

[Text] Scientists of the Ukrainian Academy of Sciences' Institute of Machine Building Problems believe that the force of such dangerous natural phenomena as tornadoes, hurricanes and storms can be measured. They have developed a physical model and methods of calculating processes of the natural circulation of liquid and gas currents.

"In order to understand the mechanism of the phenomena, we turned to the laws of thermodynamics," said Candidate of Technical Sciences B. Troshen'kin, one of the authors of the work. "After all, a storm or a tornado is a collision of air currents of different temperature, which is accompanied by intense heat transfer. Part of this heat is converted into mechanical energy which twists the layers of air with enormous velocity. As a result of friction between the layers of air, heat is evolved. Such a 'hurricane formula' permits an exact quantitative evaluation of this complex natural process."

FTD/ SNAP  
CSO: 1865/56

# INTERNATIONAL CONFERENCE ON PHYSICS OF CLOUDS

Alma-Ata KAZAKHSTANSKAYA PRAVDA in Russian 29 Aug 84 p 3

[Excerpt] Tallin, August 27--The study of laws of the origin, growth and spreading of clouds may help realize mankind's ancient dream of modifying the weather and preventing destructive natural disasters. In the course of one week, scientists from 27 countries of all the world's continents--participants in the Ninth International Conference on the Physics of Clouds, which has ended in the capital of Estonia--shared results of observations and of laboratory and field experiments.

A special session of the conference was devoted to results of the search for effective and economical ways of controlling the formation of clouds. The session noted successes of Soviet scientists who have been conducting a scientific experiment over a large territory for the purpose of protecting farm crops against hail. Important results have been obtained in the course of joint studies of precipitation accumulation made by Soviet scientists and their colleagues from other socialist countries in the interest of preventing drought.

FTD/SNAP  
CSO: 1865/322



UDC: 551.509.33

MACROSYNOPTIC CHARACTERISTICS OF EXTREMELY COLD AND EXTREMELY WARM  
DECEMBERS IN EASTERN CAUCASUS AND CASPIAN AREAS

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR, SERIYA NAUKI O ZEMLE  
in Russian No 3, 1984 pp 86-90

MAMEDOVA, S. N.

[Abstract] A study was performed to determine the specifics of circulation forming large positive and negative air temperature anomalies in December in the eastern Caucasus and Caspian areas. Atmospheric processes causing very cold and very warm December months were studied based on observations of 1953 through 1980. Extremely cold Decembers were caused by five types of synoptic processes involving anticyclones from the Azores, Siberia, and Scandinavia remaining over the European continent. Extremely warm Decembers were created by four main types of synoptic processes involving southern cyclones, stationary, Azores and subtropical anticyclones. References: 5 Russian.  
[155-6508]

UDC: 551.509

MACROSYNOPTIC CHARACTERISTICS OF EXTREMELY COLD AND EXTREMELY WARM  
FEBRUARY MONTHS IN EASTERN CAUCASUS AND CASPIAN AREAS

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR, SERIYA NAUKI O ZEMLE  
in Russian No 3, 1984 pp 105-110

ALIYEVA, G. A.

[Abstract] A study is made of anomalies in the mean monthly air temperature in February in the eastern Caucasus and Caspian area and the macrosynoptic processes associated with them. The studies were based on synoptic charts and pressure pattern charts for 1953 through 1977. The analysis shows that in February the mean monthly deviation from the normal mean monthly air temperature increases with increasing distance from the coast into the

continent. Extremely cold Februarys in the Caucasus are associated with predominance of meridonal circulation, creating favorable conditions for intrusion of cold air masses from the north through the European USSR, northern Caucasus and northern Caspian. Three main types of synoptic processes are involved, including anticyclonic circulation from norther Scandinavia or the Barents Sea, anticyclones form the Kara Sea and Siberian anticyclones. Extremely warm Februarys result from an increase in latitudinal circulation creating predominance of west-east transfer of warm air from the Atlantic Ocean into the eastern Caucasus, by penetration of southern cyclones, cyclonic activity over the European territory of the USSR and subtropical anticyclones. Figures 2; references: 4 Russian.  
[155-6508]

UDC: 551.524.4

STRUCTURE OF TEMPERATURE FIELD BASED ON OBSERVATIONS OF REFRACTION FROM  
HIGH METEOROLOGICAL MAST

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 24 Mar 83) pp 231-236

BESCHASTNOV, S. P., GRECHKO, G. M., GURVICH, A. S., ZAGORUYKO, S. V.,  
KAN, V. and FINKE, V. V., Institute of Experimental Meteorology; Institute  
of Atmospheric Physics, USSR Academy of Sciences

[Abstract] Results are presented from retrieval of vertical temperature profiles and study of the fine spatial structure of the temperature field in the atmospheric boundary layer based on observations of light refraction from the sun during sunrise and sunset. Observations were performed from a high meteorological tower at negative elevation angles. The results show that observations of refraction from the earth's surface can be used for effective study of the temperature field in the air layer below the observation point. The vertical temperature profiles computed agree with the measurement results. Since the refraction problem was solved assuming spherical symmetry of the atmosphere, studies should be made of the errors arising due to the actual nonspherical symmetry. Figures 2; references 12: 11 Russian, 1 Western.  
[160-6508]

INFLUENCE OF MOUNTAIN RELIEF ON DISTRIBUTION OF HEAT AND MOISTURE

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOGRAFICHESKAYA in Russian  
No 2, Mar-Apr 84 (manuscript received 4 Apr 83) pp 77-84

ELIZBARASHVILI, E. Sh., Geography Institute imeni Vakhushti, Georgian  
Academy of Sciences

[Abstract] Estimation of the influence of mountain relief on distribution of heat and moisture characteristics based on existing standard meteorological observations, determination of general characteristics of these distributions and development of methods for calculating temperature and precipitation as a function of steepness and orientation of slopes are the difficult tasks undertaken in this article. Two characteristic curves of temperature as a function of altitude and steepness of mountain slopes are constructed: one for wet peripheral regions of mountainous areas, another for dryer internal regions among the mountains. In terms of precipitation, peripheral slopes oriented toward the southwest and west receive the greatest precipitation. The shortage of data concerning atmospheric moisture content, particularly in high mountain regions, makes it impossible to construct an exhaustive method of calculating the moisture content as a function of altitude, orientation and location of slopes. It is found that in winter, the temperature gradient is greatly influenced by both steepness of a slope and orientation, the gradient being maximal for eastern and southern-facing slopes. Figures 5; references: 14 Russian.  
[163-6508]

MANGANESE IN RECENT SEDIMENTS OF UKRAINIAN SSR BLACK SEA SHELF

Kiev DOKLADY AKADEMII NAUK UKRAINSKOY SSR, SERIYA B: GEOLOGICHESKIYE, KHIMICHESKIYE I BIOLOGICHESKIYE NAUKI in Russian No 6, Jun 84 (manuscript received 2 Aug 83) pp 18-21

[Article by V. I. Ogorodnikov and K. S. Krasovskiy, Geological Sciences Institute, Ukrainian Academy of Sciences, Kiev; presented by Ye. F. Shnyukov, academician, Ukrainian Academy of Sciences]

[Text] Manganese, like iron, enters the Black Sea with river runoff predominantly in suspension and to a far lesser degree in a dissolved state [1]. There is considerably more dissolved Mn than dissolved Fe (4.3 and 0.4% respectively) [2]. The maximum concentrations of both dissolved and suspended manganese in the surface layer of Black Sea waters are found near the mouths of rivers. But such concentrations persist only in a narrowly local coastal zone because most of the suspended and dissolved Mn is eliminated from the water layer at the time of coagulation and precipitation in the zone of contact of river water and sea water and does not reach the open sea [3].

Entering the sea in a mobile bivalent form, the manganese is rapidly oxidized and passes into tetravalent compounds, found everywhere in the surface layer of Black Sea sediments. In the underlying horizons of sediments in the stage of early diagenesis there is a reduction of  $Mn^4$  into  $Mn^{2+}$  with the formation of a sulfide of an easily soluble form. In the upper oxidized layer of sediments (with a thickness of 0.5-2 cm), as a result of the diagenetic redistribution, there is considerably more manganese than in the underlying reduced layer [4]. Manganese, passing into the hydrogen sulfide zone, also is transformed into a bivalent easily soluble form and as a result is accumulated in the water layer. According to [5], the hydrogen sulfide zone of the Black Sea contains 100 million tons of dissolved Mn, which corresponds to a major manganese deposit.

The principal difference in the geochemistry of manganese from the geochemistry of iron is the peculiarities of its entry into the sedimentation basin, as is expressed in the separation of Mn from Fe already in the weathered crust in areas of water scouring. Manganese is more mobile than iron and is transported more intensively into the sea. In the sedimentation basin itself there is a closer correlation between Mn and the pelitic component of bottom sediments. Whereas the iron content increases gradually, with an increase in the dispersity

of the sediments, an increase in Mn concentrations is noted with an adequately high content of the pelitic fractions and increases more sharply in finely disperse sediments (Fig. 1).

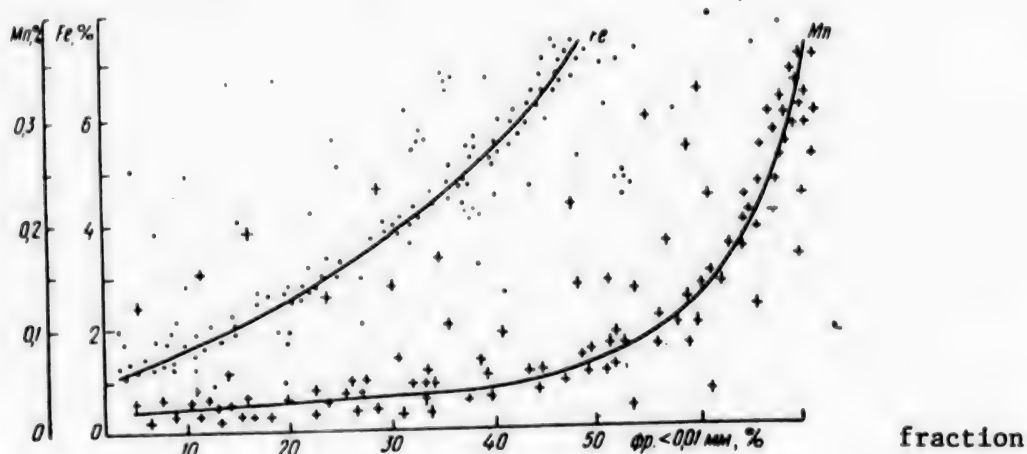


Fig. 1. Curves of dependence of concentration of iron and manganese on content of fraction  $< 0.01$  mm in recent sediments of Ukrainian Black Sea shelf.

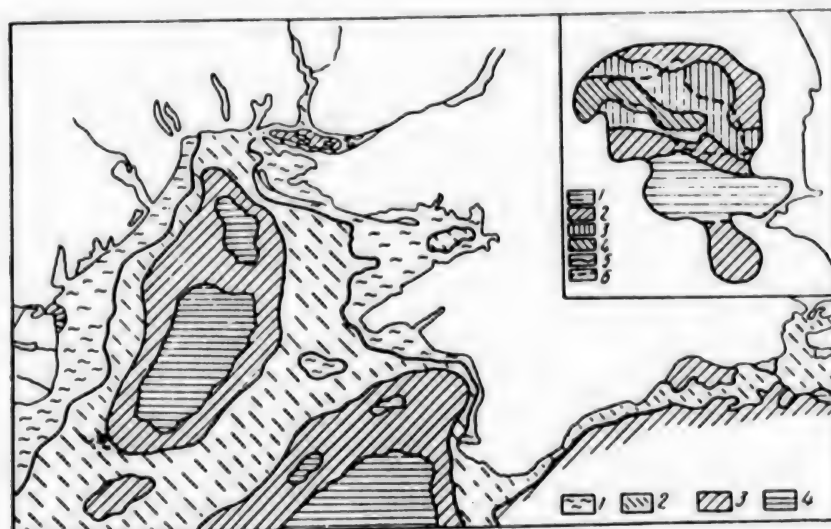


Fig. 2. Distribution of manganese in recent sediments on the Black Sea shelf of Ukrainian SSR (in % of noncalcareous matter of sediments): 1) less than 0.01; 2) 0.01-0.1; 3) 0.1-0.2; 4) more than 2.0%. In inset: Mn distribution in ferromanganese nodules of surface layer of Kalamitskoye field of nodules: 1) less than 2; 2) 2-6; 3) 6-10; 4) more than 10%; 5) limits of field of nodules; 6) limits of region with high content of nodules in sediments.



As a result of the lithological-geochemical investigations which were made the maximum manganese concentrations for recent sediments on the Black Sea shelf (more than 0.2% scaled to the noncalcareous matter in the sediments) were discovered on the continental slope adjacent to Kalamitskiy Gulf; in individual zones of the central part of the northwestern shelf and the Dnepr-Bug lagoon; in some sectors of the Kerch-Taman shelf. Zones of Mn content 0.1-0.2% are discriminated on the northwestern shelf and occupy a considerable region in its central part, in Kalamitskiy Gulf, on the continental slope of the Southern Crimea and the outer part of the Kerch-Taman shelf. The background content of Mn, in recent sediments constituting 0.01-0.1%, is propagated over considerable areas of the northwestern and southern coasts and the Kerch-Taman shelf.

The lowest Mn concentrations (less than 0.01%) are observed in the coastal regions of the Odessa-Danube sector of the shelf, Yegorlytskiy and Kalamitskiy Gulfs and the Tenderovskaya spit. Bottom sediments with minimum manganese concentrations have considerable development in Karkinitiski and Dzharlygachski Gulfs (Fig. 2).

An analysis of the manganese distribution in recent sediments as a whole reveals its low concentrations within the limits of the Ukrainian SSR shelf. A relatively intensive accumulation of Mn is observed for the most part in three regions:

1. Central part of the Dnepr-Bug lagoon, where the accumulation of Mn takes place due to receipts with sediments of the Dnepr and Southern Bug. According to data in [1], in the fluvial suspensions of the Dnepr there were maximum Mn contents (0.88%) in the pelitic fractions (0.01-0.001 mm).

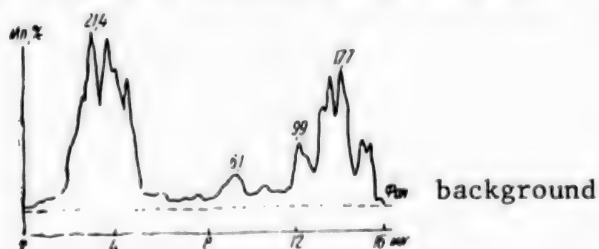


Fig. 3. Manganese distribution in nodule 174/2.

2. The Kalamitskiy Gulf region, where the manganese source is the weathered crust of Crimean Peninsula rocks, especially the reddish weathered crust of limestones of the Tarkhankut Peninsula and a thick stratum of reddish-brown clayey loams of the Al'minskaya Depression [6]. Increased Mn concentrations in water (up to  $516 \mu\text{g}/\text{dm}^3$ ) were established to the southwest of Kalamitskiy Gulf at a depth of 100 m [7, 8]. This is evidently attributable to the fact that in this sector there is an upwelling of Mn-enriched waters from the hydrogen sulfide zone.

3. The region of the outer part of the Kerch-Taman shelf, as well as individual sectors of the zone, including Feodosiya Bay. This is evidently associated with abrasion of outcrops of ferromanganese ores of the Azov-Black

Sea iron ore province [9].

The manganese content in the ferromanganese nodules in the surface layer of the Kalamitskoye field of nodules varies from 0.9 to 14.0%. In an analysis of Mn distribution in the nodules (Fig. 2, inset) it is possible to discriminate the following patterns: 1) increased Mn concentrations are observed in a region with a high content of nodules in the sediments; 2) the Mn content in the nodules decreases with increasing distance from the northwestern edge of the field where there is a receipt of transformed solutions containing manganese and iron from the hydrogen-sulfide zone [10]. It should be mentioned here that the Mn content within the nodules varies and sometimes is rather significant. According to data from an electron probe analysis with an EMMA-2 microanalyzer, the Mn content in nodules from station 174 (where, according to data from a chemical analysis the content is 6.1% Mn) varies from 2 to 28.6%; in zones enriched with manganese there is a sharp reduction in iron content (Fig. 3). Evidently, during definite periods the entry of Mn into nodules was considerably increased. This could be caused by: 1) a change in the physicochemical conditions of the sedimentation medium; 2) a marked increase in the quantity of Mn entering this region (evidently as a result of an intensification of the underflow of Mn from the hydrogen sulfide zone).

Thus, the manganese content in recent sediments of the Ukrainian SSR Black Sea shelf sharply exceeds the Clarke and only in individual regions of formation of ferromanganese nodules is it possible to trace the initial stages in the recent manganese ore process.

#### BIBLIOGRAPHY

1. Lubchenko, I. Yu. and Belova, I. V., "Migration of Elements in River Water," LITOLOGIYA I POLEZNYYE ISKOPAYEMYYE (Lithology and Minerals), No 2, pp 23-28, 1973.
2. Volkov, I. I., "Chemical Elements in River Runoff and Forms of Their Entry into the Sea (In the Example of Rivers of the Black Sea Basin)," PROBLEMY LITOLOGII I GEOKHIMII OSADOCHNYKH POROD I RUD (Problems in the Lithology and Geochemistry of Sedimentary Rocks and Ores), Moscow, Nauka, pp 85-113, 1975.
3. Mitropol'skiy, A. Yu., Bezborodov, A. A. and Ovsyanyy, Ye. I., GEOKHIMIYA CHERNOGO MORYA (Black Sea Geochemistry), Kiev, Nauk. dumka, 1982, 144 pages.
4. Volkov, I. I. and Sevast'yanov, V. F., "Redistribution of Chemical Elements in Diagenesis of Black Sea Sediments," GEOKHIMIYA OSADOCHNYKH POROD I RUD (Geochemistry of Sedimentary Rocks and Ores), Moscow, Nauka, pp 134-182, 1968.
5. Skopintsev, B. A., FORMIROVANIYE SOVREMENNOGO KHIMICHESKOGO SOSTAVA VOD CHERNOGO MORYA (Formation of Modern Chemical Composition of Black Sea Waters), Leningrad, Gidrometeoizdat, 1975, 337 pages.

6. Shnyukov, Ye. P., "Ferromanganese Nodules in Black Sea," LITOLOGIYA I POLEZNYYE ISKOPAYEMYYE, No 5, pp 71-78, 1981.
7. Mokiyevskaya, V. V., "Manganese in Black Sea Waters," DOKL. AN SSSR (Reports of the USSR Academy of Sciences), No 6, pp 1445-1448, 1961.
8. Spencer, D. W., Brewer, P. G. and Sachs, P. L., "Aspects of the Distribution and Trace Element Composition of Suspended Matter in the Black Sea," GEOCHIMICA ET COSMOCHIMICA ACTA, 36, No 1, pp 71-86, 1972.
9. Orlovskiy, G. N., Lomayev, N. A. and Usenko, V. P., "Some Features of Manganese Distribution in Sediments on Ukrainian SSR Shelf," OSADOCHNYYE PORODY I RUDY (Sedimentary Rocks and Ores), Kiev, Nauk. dumka, pp 14-19, 1978.
10. Krasovskiy, K. S., "Distribution of Aqueous Suspended Matter in Region of Kalamitskoye Field of Ferromanganese Nodules," DOKL. AN UkrSSR, SER. B. (Reports of the Academy of Sciences Ukrainian SSR: Series B), No 4, pp 17-19, 1983.

COPYRIGHT: Izdatel'stvo "Naukova dumka", "Doklady Akademii nauk Ukrainiskoy SSR", 1984

5303

CSO: 1865/266

## INTERNAL WAVES IN OCEAN

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 84 pp 40-44

[Article by A. D. Yampol'skiy, candidate of geographical sciences, G. Ye. Kononkova, candidate of physical and mathematical sciences and K. V. Pokazeyev, candidate of physical and mathematical sciences]

[Text] Who has not observed waves on the sea? The waves on its surface rarely exceed tens of meters even during the time of a storm. But in the depths of the ocean internal waves are propagated whose amplitude can attain hundreds of meters even under ordinary conditions.

\*\*\*

### Internal Waves in the Ocean

Late in August 1893 a Norwegian polar expedition on the "Fram," under the leadership of the famed F. Nansen, encountered an unusual situation: in the neighborhood of Taymyr Island, heading toward the ice edge, the "Fram" suddenly almost stopped, despite the fact that the engine was operating at full power. It would appear that the vessel was trapped. In the words of Nansen himself, "...in order to cover the short distance, which we could have rowed in a half-hour or even less, the 'Fram' required an entire watch (4 hours -- A. Ya.)." The "Fram" had entered "dead" water, an extremely singular phenomenon, usually encountered in places where above a layer of saline, and therefore denser water, there is a more or less thin freshened layer. Nansen wrote in his diary that the water taken from the surface was suitable for drinking but the water entering through the Kingston valve was too salty even for the boiler. During movement of the ship under such conditions almost all the energy of the ship's engine is expended on the formation of waves at the interface of the layers. These waves, in contrast to waves at the surface, occur extensively in the depths of the ocean.

F. Nansen sent his observations on the expedition to the well-known Swedish geophysicist and oceanographer W. Ekman. After carrying out a series of elaborate laboratory experiments Ekman established that with definite relationships between the thickness  $h$  of the upper layer, the densities  $\rho_1$  and  $\rho_2$  of the saline and freshened layers and the ship's speed  $c$  the wave resistance to movement increases sharply. Later the English hydrodynamicist G. Lamb demonstrated that if

the resistance of internal waves attains an enormous scale. The "Fram" situation, as they say, "fitted" precisely the conclusions of theory.

Seamen had also encountered "dead water" earlier, but the stimulus for in situ, laboratory and theoretical investigations of internal waves came from the communication of F. Nansen. Later it became clear that internal waves are frequently encountered in the world ocean and that this phenomenon is extremely complex. Many of its peculiarities observed in the ocean have not been explained on a theoretical basis.

#### How Internal Waves Are Formed

It must be noted that the great Norwegian observed a rarely encountered special case of internal waves in the ocean. Usually there is not such a sharp division into layers of different density: the density of sea water smoothly increases with depth, or, as oceanologists say, there is a continuous stable stratification.

Under such conditions the simplest physical model of internal waves can be represented in the following way. Assume that some elementary volume of water under the influence of some factor (an investigation of these factors is one of the important problems in modern oceanology) is displaced vertically from its position of equilibrium. If it is displaced upward, it will be surrounded by less dense water and under the influence of gravity it will tend downward to its position of equilibrium.

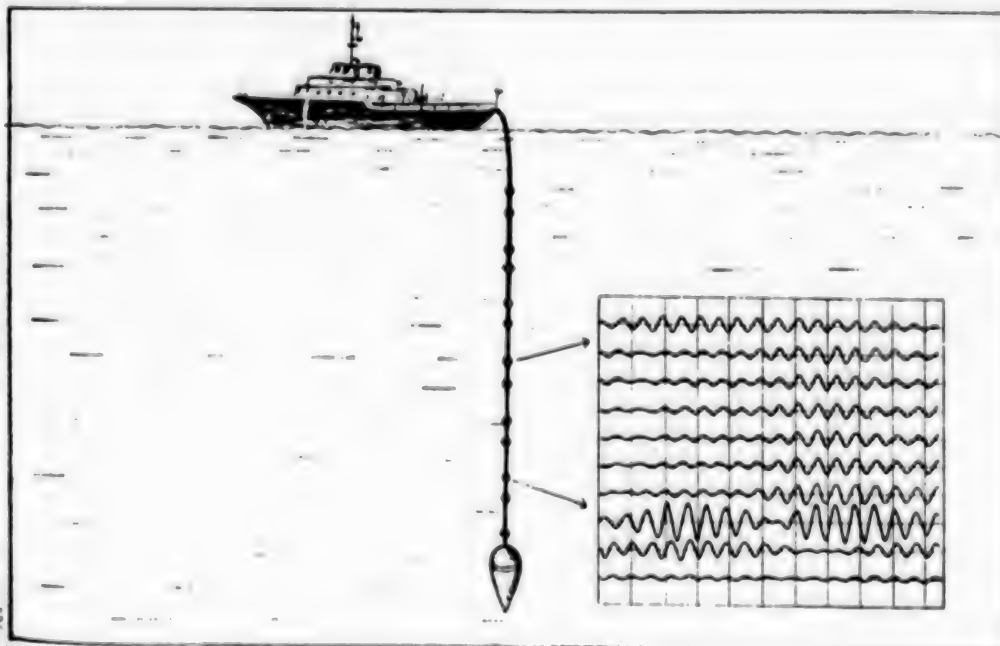


Diagram of measurement of parameters of internal waves using a single vertical. The inset shows curves constructed on the basis of sensor readings, from which the amplitudes and periods of the internal waves are determined.



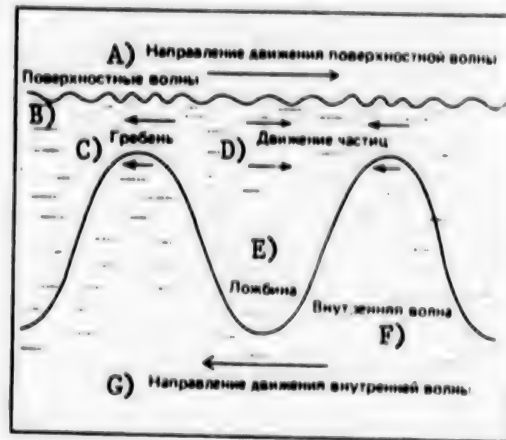
If this elementary volume is displaced downward, where the water is denser, the Archimedes force will tend to return it upward to a position of equilibrium. Naturally, left to itself the considered elementary volume for some time will oscillate about the position of equilibrium. The frequency of these oscillations is dependent for the most part on the vertical density gradient. It is named after two Scandinavian geophysicists who independently and almost at the same time derived its mathematical expression: Väisälä-Brunt frequency. Due to the fact that the vertical density gradient is usually rather small (except for extremely rare "exotic" cases) the forces impeding the displacement of particles from a position of equilibrium are also small. Accordingly, the amplitudes of the internal waves can be great and attain tens and even hundreds of meters.

It is interesting that ordinary waves at the surface of the oceans and seas also can be regarded as internal waves at the interface of two media -- water and air. But in this case the difference in densities on the two sides of the interface is great. For this reason at the ocean surface, fortunately, waves with a height of tens of meters are extremely rare and there are no 100-m waves at all. Up to this point, as a simplification, we have examined the movement of some volume of water in a vertical direction. But from vertical movement waves travel in all directions. This can be experimentally confirmed by anyone, because, as Koz'ma Prutkov once said: "Casting pebbles into the water, you look at the circles formed by them; otherwise the casting of such stones would be simply frivolous."

#### Registry Methods

Internal waves favor the mixing of ocean waters and this enriches the waters with nutrients and oxygen. Thus, knowing the peculiarities of structure of internal waves it is evidently possible to judge the prospects for the fishing industry in different regions. Investigations of internal waves are also of great importance for underwater navigation. The very fact of the existence of these waves exerts a great influence on the methods used in oceanological measurements. And, in actuality, if it is necessary to get some idea concerning the properties of water at some fixed depth, strictly speaking this cannot be done by means of direct measurements without allowance for internal waves.

As might be expected, a determination of the parameters of internal waves involves certain difficulties. Only recently oceanologists judged the height of internal waves, for example, from the readings of an instrument registering the temperature of sea water at a fixed depth: the temperature difference during an interval comparable with the period of internal waves is proportional to their height. However, for this it must be assumed that the vertical temperature gradient is known and that it is constant in time. As measurement techniques developed more modern multielement sensors came into use for determining the height and period of internal waves. Each sensor usually consists of a wire resistance thermometer with a length of several meters, two point temperature sensors near its ends and a depth sensor. The basic wire resistance thermometer measures the mean temperature in this layer and makes it possible to avoid its small fluctuations caused by microscale turbulence.



Influence of internal waves on surface waves. With the passage of the crest of the internal wave the orbital velocity of movement of water particles coincides with the direction of wave propagation. With passage of the troughs the particles move in the opposite direction. In this case the surface and internal waves travel toward one another. Therefore, the surface waves, being above the crests of the internal waves, are acted upon by a countercurrent which "compresses" the waves at the surface and they become shorter and steeper. Over the troughs of the internal waves, due to the accompanying current, the waves at the surface are "drawn out," becoming longer and gentler.

**KEY:**

- A) Direction of movement of surface wave
- B) Surface waves
- C) Crest
- D) Movement of particles
- E) Trough
- F) Internal wave
- G) Direction of movement of internal wave

The point sensors ensure the registry of the vertical temperature gradient. Usually a single cable carries several tens of such multielement sensors at fixed distances from one another, forming a measurement vertical. The signals from all these sensors are sent to a shipboard electronic computer. In this case it is no longer necessary to make assumptions concerning the vertical temperature gradient. But on the basis of measurements on a single vertical it is impossible to judge the length, velocity and direction of propagation of internal waves. In order to obtain such information it is necessary to make measurements simultaneously on several verticals. If these verticals are situated at the vertices of a triangle, it is possible to determine the velocity and direction of propagation of the internal waves, as well as their length. In actuality, by knowing the length of the sides of the triangles, as well as the appearance of any distinguishing characteristic of internal waves (such as a characteristic increase or decrease in amplitude) on each of them, from simple geometrical considerations it is possible to obtain information on these parameters of internal waves in the measurement region.

It must be remembered that such measurements are carried out in the open ocean, far from the shores, at a depth of several thousands of meters. There the setting up of even a single measurement vertical is a complex and time-consuming operation. As such a vertical it is possible to use, for example, a self-contained buoy station, consisting of an adequately large buoy at the surface and a heavy anchor at the bottom. The cable connecting them is the "vertical" on which instruments can be suspended.



Simulation of influence of internal waves on surface waves in glass laboratory flume. It is possible to see the boundary to the right of which the picture of surface waves changes, being acted upon by an internal wave.

Neutral buoyancy floats are an interesting and indeed a promising source of information on internal waves. This extremely solid structure, which is in equilibrium in a definite layer, remains there a long time and together with the particles of this water layer experiences oscillations in the vertical and horizontal planes. Periodically the float "reports" on its spatial position and the processing of such communications makes it possible to judge the parameters of internal waves in the region where the float is situated.

#### Surface Manifestations of Internal Waves

The waves "living" in the depths of the ocean must necessarily somehow be manifested at the surface. And oceanologists relatively recently noted this. But these oscillations are evidently very small and it is by no means simple to discriminate them against the background of considerably larger surface waves. But in this case nature, as they say, met us half-way. In the Arctic Ocean the ice extinguishes the surface waves and sometimes can serve as an indicator of movements associated with internal waves. Measurements of water temperature at different horizons beneath the ice (which give the parameters of internal

waves) in combination with precise determinations of the slopes of floes, made it possible to register the correlation of these phenomena reliably.

It was found that over the crests and troughs of internal waves the spectra of surface waves differ from one another. The influence of internal waves on surface waves can be represented schematically as follows. In the upper part of the crest of both internal and surface waves the orbital velocity of movement of particles in the wave is directed along the movement of the wave, whereas in the lower part of the trough it is directed in the opposite direction. Probably the surface waves over the crest of the internal wave and over its trough are in different conditions. In the simplest case, when the surface and internal waves run toward one another, the waves which were over the trough are acted upon by an accompanying current, whereas over the crest they are acted upon by a countercurrent. The accompanying current "draws out" the waves and they become longer and more gently sloping, whereas the countercurrent "compresses" them and they become shorter and steeper. The sectors of the ocean surface where the height and the period of the waves changed under the influence of internal waves can differ substantially in external appearance from the surrounding ocean area. Such zones with modified wave parameters are easily visible from aircraft and even from space.

The influence of internal waves on surface waves is strongest in the case of some definite relationship between the velocities of internal and surface waves running toward one another. In this case such a countercurrent arises over the crest of the internal wave that the surface waves at this point can be completely stopped or even be reflected from it as from an obstacle. This phenomenon is called the blocking of surface waves. It is possible to see the blocking of surface waves by the countercurrent by carrying out an experiment in a glass laboratory flume. In order to simulate the influence of internal waves the bottom is given the form of the crest of an internal wave, as a result of which the necessary change in current velocity along the flume is attained. Waves of a stipulated period ( $2/3$  of a second) are generated in the trough by a cylindrical wave generator. A theoretical analysis shows that the length of the surface waves and their velocity are complexly dependent on their periods, the surface tension of the water, and also on the intensity and direction of current velocity. Accordingly, with a constant period of the waves (in our case  $2/3$  of a second) their length and velocity can be very different, depending on the current velocity. Since the current velocity changes along the flume, the length of the waves in different parts of the flume is different.

If somewhere in the flume the velocity of the waves and the velocity of the countercurrent conform to some relationship, the blocking of waves will occur here. After blocking the length and velocity of the waves will continue to decrease. The velocity of the countercurrent also decreases. Thereafter the waves at the surface, retaining their period constant but decreasing their length by several times, are propagated in the same direction in the form of small waves. In the open ocean there are similar processes of transformation of surface waves in currents generated by internal waves.



## Slicks

Thin films of surface-active substances can be found virtually everywhere on the surface of the seas and oceans. They appear as a result of the natural vital functions of marine organisms or sea contamination. Internal waves, giving rise to variable currents at the surface, exert a substantial influence on the film of surface-active substances. Thus, over the sectors between the troughs and crests of internal waves the concentration of film matter increases or decreases. As a result, in calm weather slicks or slick zones appear at the surface of the oceans and seas (from the English word meaning smooth, shiny). Such zones show up beautifully to the naked eye even when there are small waves and a weak wind.

If the slicks are drawn out into long parallel bands it is extremely probable that internal waves are responsible for the generation of the bands. In this case the velocity of movement of the slick zones is equal to the velocity of the internal waves and the distance between the zones is equal to the length of the waves generating them. The width of such bands is dependent on both the amplitude of the internal waves and on the velocity of the wind blowing over the ocean surface. It is interesting to note that whatever may be the parameters of internal waves, if the wind velocity is greater than 5-6 m/sec no slicks will be observed.

When there is a stronger wind, when there are no longer slicks, films of surface-active substances "help" in the registry of effects at the surface caused by internal waves. The fact is that these films, especially fatty films, strongly extinguish short wind waves. Jules Verne tells about this in a graphic way in the "Fifteen-Year Old Captain": "If whale oil is poured onto the water surface when the 'Pilgrim' passes through the surf, for an instant this will calm the waves and facilitate passage of the ship across the reef." And he goes on: "...the sailors stood at the prow near the barrels of oil, awaiting the captain's order: 'Away with the blubber oil!' cried Deek, 'Look alive!' Beneath this layer of oil, which was poured in streams onto the waves, the sea grew calm, as if by magic, but a minute layer raged with doubled fury."

To be sure, the film of surface-active substance usually encountered in the ocean cannot so effectively extinguish waves, but the appearance of regions differing from adjacent sectors of the ocean is entirely probable. Such regions can also be detected by remote methods, such as radar or optical. Thus, it is possible to judge the parameters of internal waves without carrying out direct measurements. Radar sets on ships and aircraft are being used successfully for the detection of slicks or regions with an increased concentration of surface-active substances because the nature of reflection of radio waves here differs considerably from the surrounding ocean area. The same principle is applicable when using optical methods: the reflection of light from the considered sectors of the ocean surface and the surrounding ocean area is also extremely different.

The changes in the concentration of surface-active substances and the parameters of surface waves also exert an influence on the emissivity of these



regions in the infrared range. Accordingly, for the study of internal waves it is possible to use devices for measuring infrared radiation of different types on aircraft and satellites.

Intensive investigations of internal waves which are being carried out by oceanologists of different countries will undoubtedly lead to the discovery of new and important features of internal waves.

COPYRIGHT: Izdatel'stvo "Nauka" "Zemlya i Vselennaya", 1984

5303

CSO: 1865/296

### THIRTY-SEVENTH CRUISE OF 'AKADEMIK KURCHATOV'

Moscow ZEMLYA I VSELENNAYA in Russian No 4, Jul-Aug 84 pp 78-83

[Article by V. I. Voytov, expedition chief]

[Text] Search for Space Particles in Depths of Ocean

In 1960 Academician M. A. Markov advanced the idea of registry of high-energy muons and neutrinos in the ocean. The use of water layers instead of rocks has definite advantages: in the ocean, especially far from the shores in the subtropical and tropical latitudes, it is extremely homogeneous in its physico-chemical properties. In addition, ocean water not only absorbs, but also generates Vavilov-Cerenkov radiation which can be used for the detection of particles. Several years ago the international project DYUMAND was announced and within its framework plans were made for a study of high-energy muons and neutrinos (ZEMLYA I VSELENNAYA, No 1, p 13, 1979 -- Editor's note).

Since 1981 the scientific research ships of the Oceanology Institute imeni P. P. Shirshov, USSR Academy of Sciences, have been used in carrying out investigations for the purpose of studying the energy spectrum of high-energy muons by an optical method. On the third cruise of the "Professor Shtokman" in May-June 1981 in the Atlantic Ocean there were tests of an abyssal muon detector (GDM -- glubokovodnyy detektor myuonov), developed at the Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences. During the year which followed in the Oriente Basin in the Caribbean Sea it was possible to register muons to a depth of 4,000 m. On the 37th cruise of the "Akademik Kurchatov," the flagship of our scientific research fleet, work shifted from trial registry with the GDM to work at great depths (to 5,000 m). Two prolonged series of observations could be made in this same Oriente Basin (at the horizons 2,000 and 4,000 m).

This was the first DYUMAND test area where simultaneous studies were made of the passive oceanological background: the hydrological and hydrochemical characteristics of the water layer, the parameters of the active background. The latter include the radioactive isotopes  $K^{40}$  and  $Ra^{226}$ , which, experiencing beta decay, generate Vavilov-Cherenkov radiation. Unfortunately, there was no study of the luminescence of abyssal organisms which cause considerable interference in the registry of high-energy space muons. In the future plans call for accomplishing this using the abyssal bathyphotometer developed at the Biophysics Institute, Siberian Department, USSR Academy of Sciences.

The optical properties of the waters of the Oriente Basin were investigated in samples taken from a depth of 6,000 m. It was found that the water layer here is virtually homogeneous and is extremely transparent. It is true that in the depression, as indicated by an analysis of the composition and stratification of bottom deposits, there is a high probability of slides of sediments from the steep continental slope of the depression, which should result in periods of increased turbidity of deep Oriente waters.



Track of the 37th cruise of the scientific research ship "Akademik Kurchatov." The dark squares represent DYUMAND test areas.

#### Trans-Atlantic Run

The second DYUMAND test area was selected in the center of the ocean on the main Trans-Atlantic track of the expedition, running along latitude  $22^{\circ}20'N$  from the African shelf approximately to  $67^{\circ}W$ . Here geological-geochemical work was done, as well as hydrophysical (optics, hydrology) and biological investigations, which were necessary not only for implementation of the program itself, but also for selecting the place for the DYUMAND test area.

The position of the run in the Trade Winds and Trade Currents zones ensured stable conditions, making it possible to carry out work under the DYUMAND project far from the principal tracks of tropical cyclones. The optical properties of the waters of the central Atlantic are close to those which are characteristic of the south tropical waters of the Pacific Ocean and the Sargasso Sea. In these regions of the Atlantic and Pacific Oceans a standard white disk with a diameter of 30 cm disappears for the eye at a depth of 60-70 m, whereas in the Baltic, for example, it is invisible to the observer after submerging for only 10-12 m.

As is well known, the optical properties of sea water are essentially dependent on plankton content. The Central Atlantic is among the oligotrophic regions poor from the biological point of view. The expedition biologists found that here the quantity of mesoplankton is only 0.04 specimen per cubic meter of water. The content of mineral particles also changes the optical properties

of sea water. The particles are transported into the ocean by water and through the air. Near the shores of Africa the transparency of the water decreases sharply due to the abundance of dust arriving from the Sahara. The dust so saturates the air that the visibility is the same as in a dense fog. It is not without reason that the ancient Arabic navigators called the coastal region near the Sahara the "sea of gloom." The transport of very fine dust from the Sahara is registered even along the shores of America. The Sahara "source" releases the dust in batches. The meteorologists accompanying the expedition observed a decrease in atmospheric transparency far from the shores of Africa, associated with the next batch of dust arriving from the greatest desert on the planet. Advancing westward, for some time we were in the "Sahara dust pocket," also moving in a westerly direction.

Work in the DYUMAND test area was carried out on the way back along the Trans-Atlantic run, after visiting Mexico, Cuba and Curacao. A call at the Mexican port Vera Cruz was particularly memorable.



Abyssal muon detector.

#### In the Ancient Land of Mexico

Present-day Mexico is experiencing not only a petroleum "boom," but an archeological "boom" as well. All this began when a human head cut from a block of black basalt was discovered in one of the remote corners of the state of Vera Cruz. Some specialists were of the opinion that the facial features were indicative of an African origin. The basalt sculpture was named the "African's head." It was postulated that the creators of the ancient culture in the New World were emigrants from the "black" continent. However, these hypotheses were not valid. The human head with the seemingly negroid features and numerous other objects of material culture later found in the swamps and jungles of the states of Vera Cruz and Tabasco belonged to the culture of the Olmecs.

This people is also mentioned in the traditions and legends of the Aztecs. In Aztec the word "Olmec" means "inhabitant of rubber country" (Olman -- rubber country). As is well known, rubber has long been produced specifically in the Mexican states of Vera Cruz and Tabasco. For the time being it has not been precisely established in what language the Olmecs spoke and what they called themselves. In the opinion of the Soviet historian V. I. Gulyayev, in the remote past in Mexico and Central America there was a large group of related tribes who spoke in different dialects of the language of the ancient Maya, the Olmecs probably among them.

We were able to familiarize ourselves with the material culture of the still largely mysterious Olmecs in the capital of the state of Vera Cruz, the city of Jalapa. The treasures of the Olmec civilization are concentrated there, in the Anthropological Museum. In a specially equipped room we saw the famed "African's head" and several gigantic stone sculptured images. In the opinion of specialists these are the sculptured portraits of real personages from Olmec history, possibly chiefs or military leaders. Each wears a headgear resembling a helmet.

Mexican archeologists have reproduced Olmec cities in models. The cities were well built: stone troughs extended from the artificial reservoirs to the houses, these being a sort of water supply pipes; outside the city limits there were corn fields and kitchen gardens. The alluvial lands along the Coatzacoalcos River and its tributaries were the most fertile.

During excavations in the ruins of Olmec cities archeologists more than once found statuettes of blue-green nephrite depicting an unusual being -- like a man-jaguar. A stylized head of a jaguar can also be seen on the handles of obsidian tools. Basalt and nephrite sculptures and clay masks depicted not only gods, priests or chiefs, but also ordinary people. Here it is impossible not to note the high mastery of the ancient sculptors, who were able to convey the character of the personages and the subtleties of their moods.

The Olmecs lived in the southeastern part of modern Mexico, but their influence also extended to neighboring lands. It is postulated that among this people trade played the same role as, shall we say, the Phoenicians. Olmec merchants, collecting information on neighboring countries, thereby laid the way for the penetration of their army. Subjugated tribes also undoubtedly participated in the creation of their powerful state, cities and structures. The Olmec priests, evidently, were versed in astronomy and had a calendar.

It is postulated by historians and archeologists that the Olmec civilization began to develop approximately 3,500 years ago and flourished at about the beginning of the Christian era. However, in the 6th century A.D. certain events occurred leading to the death of the Olmec civilization. The Mexican scientist C. Senil, working at the Jalapa museum, made a surprising discovery. He excavated an Olmec city where he discovered a great many headless basalt statues. C. Senil called it Sin Cabezas ("Headless"). M. Ko, a professor at Yale University, postulated: the statues of the gods and priests were ruined intentionally. Their executioners were peasants, artisans and tribes subordinate to the Olmecs who revolted in the 6th century A.D. They expelled or annihilated the Olmec nobility and dealt with the statues personifying the oppressors.



Then the rebels departed from the cities and possibly settled among friendly tribes. But, to be sure, this is only a hypothesis.

There have been many new finds, but the origin of the Olmec civilization nevertheless remains mysterious. The most improbable hypotheses are being advanced. Among them are the following: the Olmecs are descendents of the people of Atlantis or even people from other planets (a hint is the "space helmet" shown in the sculpture).

#### Is the Ocean Becoming Warmer?

Before carrying out work on the transoceanic run (but now in an easterly direction) a hydrophysical survey was made in a test area with the center at the coordinates: 09°50'N and 54°22'W. Here a fine stepped structure of the temperature fields was recorded, rather rare for the open ocean.

Lenses of freshened water, associated with transport of waters from the Amazon, were discovered in a test area (measuring 60 x 60 miles) in the ocean. One of the lenses was "old," the other was "fresh." The latter seemingly advanced on its predecessor. The salinity in the "fresh" lens was 3.50/00 lower than is usually the case at these latitudes. One gets the impression that the investigated region between the Guiana Current and the branch of the Inter-trades Current in its hydrodynamic features constitutes a singular "graveyard" of freshened lenses. Arriving here, the lenses no longer significantly move apart, but slowly rotate. It is interesting that the lenses, not differing in transparency from the surrounding waters, and not being an additional light scatterer, nevertheless disrupt the conditions for the vital functions of plankton in the water layer.

A comparison of the temperature values in the water layer of the transoceanic run and data for the preceding decades indicates that the surface layer of the ocean itself has become warmer by approximately a half-degree.

The expedition carried out geological and geochemical work on the run. A study was made of types of bottom sediments and the cycle of sedimentation in the north tropical zone of the Atlantic was evaluated (from the recent deposits to the Middle Pleistocene). Directly aboard the ship a thorough geochemical analysis was made for determining the rocks which were raised. At the center of the ocean in the transition region from the Mid-Atlantic Ridge to the abyssal zone the expedition discovered deposits of ferromanganese nodules, including those of a spherical shape, rare for the Atlantic Ocean.

In the DYUMAND test area in the southwestern part of the Canaries Basin the abyssal muon detector was used in registering muons to a depth of 5,000 m. A study of the absorption of muons makes it possible to determine an important physical parameter -- the energy spectrum of cosmic muons at sea level, which reflects both the regularities of interactions in the high-energy region and the characteristics of primary cosmic radiation. As a result it was possible to determine the energy spectrum of muons and to clarify the characteristics of primary cosmic radiation. A knowledge of the energy spectra of muons is a necessary stage for experimental studies of the physics of high-

energy neutrinos, which is directly related to the solution of main problems in the DYUMAND project. After the work in the DYUMAND test area the eastern part of the transoceanic run was completed.

In the tropical latitudes along the shores of Africa in the shelf zone itself and near it there was a zone of biologically productive waters associated with an upwelling (ZEMLYA I VSELENNAYA, No 1, p 30, 1971 -- Editor's note). This area has the name "Canaries upwelling," one of the popular places for the fishing trade in the Atlantic. Naturally, a knowledge of the "mechanism" of the effect of the upwelling and the different situations developing in this case are of great practical importance for the industry.

During the cruise it was possible to make two quite detailed hydrophysical surveys in a part of the Canaries upwelling from 21°N to 22°30'N, which established the spatial-temporal variability of the hydrophysical fields under two different situations. The first survey was made late in September under ordinary conditions when the Northeast Trades blew and colder and more saline subsurface waters rose from a depth of 140-180 m. After 10 days the survey was repeated but winds of westerly and southerly directions prevailed and the upwelling was considerably weakened. Now we have already found at the surface only individual spots of cold water rich in mineral salts rising from the depths. This was also immediately reflected in the intensity of the trade: fish became fewer in numbers.

The value of our work in the Canaries upwelling is not only in detailed hydrological investigations, but also while the ship was proceeding on course and at stations it was possible to obtain hydrooptical, hydrochemical and biological data, which, in particular, in the future will make it possible to develop speedy optical methods for the detection and interpretation of biological fields in zones of upwellings.

#### Visit to the Canaries Islands

Between two surveys of the Canaries upwelling the "Akademik Kurchatov" visited the capital of the Canaries Archipelago, the port of Las Palmas. Today the Canaries constitute a main center of European tourism. The gentle climate, the warm ocean and the excellent beaches attract a multitude of tourists.

Homer, Plutarch and Plato long ago mentioned the "Happy Islands" which lie beyond the Gates of Hercules. Many present-day historians feel that reference was specifically to the Canaries Islands. Europeans met with the native inhabitants of the Canaries, the Guanches, in the 14th-16th centuries, and according to their description the Guanches were blue-eyed and fair-haired giants. It was therefore postulated that the real homeland of the Guanches was Northern Europe. There are other versions, and even the fantastic version, that the Guanches are the descendents of the people of Atlantis, heading here after the death of the mythical island...

The conquest of the archipelago and its colonization took place in the late 14th century under King Henry III, and after two centuries the beaten but unconquered Guanches completely disappeared. Artificial terraces with fertile soil which the Guanches transported from the valleys in plaited baskets

remained in the mountains. The Guanches cultivated bananas which the European navigators had brought here from the Malacca Peninsula. Now Canaries bananas are one of the items of local export.

In the mountains the Guanches also left behind them hand-dug furrows for the collection of rain water. The Europeans, populating the lowland foothills, also dug ditches and channels in the sun-parched land leading to artificial lakes. And this is not surprising because in the Canaries fresh water is the most precious commodity.

Today it is not tourism alone which supports the Canaries. Even in the day of ships with sails seaports were established on the two largest islands of the archipelago where European ships stopped before sailing to the New World. There are many fishing ships in the harbors of the Canaries. Some call in order to take on fresh food and greens, others stop for repairs and still others are based in Canaries ports, especially tuna boats...

After completing all the oceanic work the expedition carried out detailed echo sounding survey work in the northwestern part of the Canaries Basin. The presence of a depth reading of 6,293 m on all maps of the Atlantic Ocean did not cause any doubts as to the reality of the Monaco depression. However, a careful survey did not reveal depths greater than 5,530 m at the point designated on the maps. In all probability a depth of 6,293 m, and with it the contours of the depression, appeared as a result of one-time erroneous measurements.

In summarizing our research under the program of the 37th cruise it can be said that the resulting hydrophysical data, biological, geological and geochemical materials deepen our knowledge concerning the nature of the Atlantic Ocean. A substantial contribution to the development of research under the DYUMAND program was also made.

COPYRIGHT: Izdatel'stvo "Nauka" "Zemlya i Vselennaya", 1984

5303

CSO: 1865/296

## 'UNSinkABILITY' OF FERROMANGANESE NODULES

Moscow PRIRODA in Russian No 3, Mar 84 pp 112-113

[Article based on materials given in DOKLADY AKADEMII NAUK SSSR, Vol 272, No 2, pp 432-437, 1983]

[Text] Among the mineral resources of the world ocean particular attention is being given to ferromanganese nodules due to their accessibility for study. It is paradoxical that in some regions of the ocean ferromanganese nodules over the course of thousands and millions of years can remain at the surface of oozes. It is known that the rate of ooze accumulation is millimeters per thousand years, whereas the mean rate of growth of nodules is millimeters per million years. It would seem that before a nodule increases its diameter by at least a millimeter it would be buried by a layer of sediments from several centimeters to several meters. Nevertheless this does not occur. An attempt has been made to explain the "unsinkability" paradox on the basis of seismic trembling, gravitational slippage of bottom material, the activity of underwater currents and even marine fauna, which move sediments from the upper part of the nodules under the lower part.

However, in the opinion of I. N. Goryainov and G. I. Goryainova (All-Union Scientific Research Institute of Geology of Mineral Resources of the World Ocean, Leningrad Polytechnic Institute imeni M. I. Kalinin), the effect of such factors has a local and to a considerable degree random character. The globality of occurrence of "unsinkable" nodules, however, must be related to factors constantly operative over the entire extent of the world ocean. These may be the elastic-plastic-viscous properties of layers of slowly forming oozes, intermediate between a fluid and a solid. Like fluids they transmit external pressure uniformly in all directions; like solids they have structural strength, resistance to shear and compressive strength. The accumulation of sediments is accompanied by the continuous compaction of ooze; in its upper layers there are clayey suspensions in its upper layers and a change in the degree of dispersivity of sediment, its aging and dehydration. With an increase in the concentration of clayey particles to 0.5-1% aggregates are formed in the suspension; these are chains which are gradually transformed into a three-dimensional coagulation lattice. Accordingly there is a marked increase in plastic strength.

Due to the compaction (compression) of the ooze the part of the nodules submerged in the newly forming ooze experiences more pressure than the

remaining part, which is under the influence of hydrostatic pressure. If the vertical component of compression is greater than the weight and forces of cohesion (adhesion) of the nodule with the ooze, the nodule will be pressed upward by the sediments, increasing in density, until there is equilibrium with the oppositely directed forces. As a result, the nodule can float above the surface of the ooze, which is increasing in density. Computations have shown that the plastic strength and pressure of the silt, increasing in its density (with a density up to  $1.6 \text{ g/cm}^3$ ), are adequate for extruding ferromanganese nodules with a density of  $1.91\text{--}1.95 \text{ g/cm}^3$  and keeping them afloat. The low rates of the process of formation of sediments favor the extrusion of nodules from oceanic ooze, which is increasing in density, and the maintenance of the nodules in a constant stable position.

COPYRIGHT: Izdatel'stvo "Nauka", Moskva "Priroda", 1984

5303

CSO: 1865/228



# RESEARCH SHIP 'VITYAZ'' COMPLETES ATLANTIC-MEDITERRANEAN CRUISE

Moscow PRAVDA in Russian 2 Oct 84 p 3

[Article by A. Androshin]

[Text] Novorossiysk, October 1--The scientific research ship "Vityaz'" has returned to this port following a 75-day absence from the Motherland.

Participants in the large-scale geological-geophysical expedition on board this ship made studies of a number of submarine mountains in the Mediterranean Sea and the East Atlantic. The expedition was organized by the USSR Academy of Sciences' Institute of Oceanology. During the cruise, the summit portions of these mountains were examined for the first time with the assistance of aquanauts and various kinds of modern technical equipment, particularly manned submersible craft.

Twenty-seven dives by the submersible "Argus" yielded interesting information which enabled the scientists to draw a well-founded conclusion regarding the geological nature of a number of submarine mountains. Five dives of a diving bell helped the scientists to obtain, for the first time, an extensive collection of rock specimens from these summits.

Researchers from Bulgaria, Italy and Greece worked successfully with the Soviet scientists on board the "Vityaz'". The ship's crew contributed much to the execution of the scientific program.

Another vessel of this expedition, the "Rift", will be approaching home shores in a few days.

FTD/SNAP  
CSO: 1865/90

OFFSHORE DRILLING AND RESEARCH VESSEL 'POLIGON'

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 25 Sep 84 p 2

[Article by V. Kurapin, (Yaroslavl)]

[Text] Shipbuilders of the Yaroslavl' Shipbuilding Plant have launched a new vessel, the "Poligon", which is intended for underwater drilling of engineering-geology boreholes in coastal shelf regions. The "Poligon" will serve simultaneously as a scientific testing laboratory. It is equipped with special lowering-and-hoisting and towing devices for the testing of offshore geological-surveying and oil field technology. The vessel has a computer center for processing data on rock specimens taken from the seabed.

FTD/SNAP

CSO: 1865/82

RESEARCH SHIP 'AKADEMIK SHULEYKIN' COMPLETES NORTH ATLANTIC CRUISE

Leningrad LENINGRADSKAYA PRAVDA in Russian 26 Sep 84 p 4

[Article by A. Kozlovskiy]

[Text] The scientific research ship "Akademik Shuleykin" has returned to Leningrad after completing a three-month cruise in the North Atlantic.

Comprehensive research was carried out in the Norwegian and Greenland seas, in line with the extensive program "Razrezy" (cross-sections).

The development of atmospheric processes over northern Europe and in the European part of the USSR and the formation of the ice mass of the Central Arctic Basin are determined to a substantial extent by the amount of heat transferred by the North Atlantic Current and air flows which form in the vicinity of Iceland. And not by chance was the determination of characteristics of the thermodynamic state of the ocean in the waters of the Norwegian energy-active zone one of the main tasks of the "Razrezy" program.

FTD/SNAP  
CSO: 1865/82

OBSERVATORY'S RESEARCH SHIPS CRUISE BALTIC AND NORTH SEAS

Vilnius SOVETSKAYA LITVA in Russian 5 Aug 84 p 4

`[Article by V. Butkus]

[Text] A new vessel, the "Vil'nyale", has been added to the scientific research fleet of the Klaypeda Hydrometeorological Observatory. This vessel is intended for the study of currents and other hydrologic data in the coastal zone of the Baltic Sea. Incidentally, oceanologists and hydrochemists of the new vessel are now pursuing comprehensive studies whose results will be needed by the builders of the Klaypeda--Mukran international ferry.

Three scientific research vessels are now registered at Klaypeda. The "Lev Titov" and the "Okeanograf" are cruising both the Baltic and the North seas.

FTD/SNAP

CSO: 1865/332

RESEARCH SHIP '17th TRADE-UNION CONGRESS' COMPLETES PACIFIC CRUISE

Moscow TRUD in Russian 20 Jul 84 p 4

[Article by A. Isayev, (Gelendzhik)]

[Text] The scientific research ship "17th Trade-Union Congress" of the Southern Marine Geology (Yuzhmorgeologiya) Production Association has returned from a long-distance cruise in the waters of the Pacific Ocean.

"During the cruise, floor relief was studied and mineral resources were prospected that are located at great depths of the world's oceans", related I. Glumov, general director of the "Yuzhmorgeologiya" production association.

Information that was obtained was processed directly on board the ship with the aid of a computer. The expedition was headed by V. Lebedev, and the motor ship was commanded by Captain B. Omel'yanets. The cruise lasted 11 months.

FTD/SNAP  
CSO: 1865/298



REPORT ON NON-MAGNETIC VESSEL'S MEDITERRANEAN-ATLANTIC CRUISE

Leningrad LENINGRADSKAYA PRAVDA in Russian 24 Aug 84 p 1

[Article by S. Nikonov]

[Text] "We have begun work in the vicinity of the Canary Islands." This report from the schooner "Zarya" was received yesterday at the Institute of Earth Magnetism, Ionosphere and the Propagation of Radio Waves.

The world's only vessel that is completely non-magnetic is making its 25th cruise--one of the longest and one of the fullest, from the standpoint of its scientific program, in recent years.

It was reported at the institute that the "Zarya" carried out a series of magnetic observations in the Mediterranean Sea in the course of its cruise. Superprecise measurements of magnetic-field anomalies between Sardinia and Africa will help solve the question of the origin of the Mediterranean Basin. It has been hypothesized that this sea is a remnant of an ancient ocean which disappeared after the African continent's plate moved toward Europe.

Results of the work in the vicinity of the Canary Islands also promise to add many new things to our knowledge of the geological past of the Atlantic Ocean. It is in this area that many scientists have placed legendary Atlantis--an ancient land which some claim disappeared into the ocean's depths about 12,000 years ago.

The "Zarya" is expected to return to Leningrad in mid-October.

FTD/SNAP

CSO: 1865/56

## STUDIES OF ATLANTIC SUBMARINE MOUNTAINS WITH SUBMERSIBLE CRAFT

Moscow PRAVDA in Russian 15 Sep 84 p 6

[Article by A. Androshin, special correspondent on board the ship "Vityaz'"]

[Excerpt] The submarine mountain Ampere, which is located in the Atlantic Ocean west of Gibraltar, has become the latest object to be examined in detail with the aid of new technology, at the disposal of the comprehensive geological-geophysical expedition now on board the scientific research ships "Vityaz'" and "Rift".

The manned submersible "Argus" carried geologists down 12 times to this mountain's summits. In addition to this, participants in the expedition observed the summits almost daily with the aid of an unmanned towed craft. Finally, divers in a diving bell reached depths of 100 and 105 meters three times. And every time they returned with a substantial load: specimens chipped from the mountain's walls and, above all, spatially oriented specimens.

"On Ampere mountain, we are dealing with a remarkable creation of nature," explained Professor Vyacheslav Yastrebov, head of the expedition. "The first detailed studies of numerous 'structures' there have already shown that they were formed by basalts which flowed from Earth's interior during the period when the volcano was active. Magma evidently rose through cracks in soft rocks, which subsequently eroded and disintegrated through the action of currents, wind and waves. The basalts that had hardened and were stronger remained, retaining their peculiar original shape. The surfaces of these rocks subsequently became covered with cracks. This is what creates an illusion of masonry when the rocks are viewed from a distance.

"Diver Anatoliy Yurchik performed an interesting experiment which confirmed these inferences. Emerging from the diving bell at a depth of 105 meters, he gathered specimens of what appeared to be 'masonry.' At the same time, he carefully examined the space between so-called walls. What appeared man-made from a distance turned out in fact to have been created by nature over the course of many thousands of years."

The scientific research ships "Vityaz'" and "Rift" now are sailing to the summit of the submarine mountain Josephine.

FTD/SNAP

CSO: 1865/71

NEW RESEARCH SHIP 'PETROV' ASSIGNED TO GEOCHEMISTRY INSTITUTE

Moscow IZVESTIYA in Russian 24 Sep 84 p 1

[Article by L. Khitrov, head of the expedition on board the scientific research ship "Akademik Boris Petrov"]

[Excerpt] The scientific research ship "Akademik Boris Petrov" is setting out from Leningrad on its first cruise. It is the lead vessel of a new series being built for the USSR Academy of Sciences by Finland's "Hollming" firm, to the order of the all-Union association "Sudoimport". The academy's Institute of Geochemistry and Analytical Chemistry imeni Vernadskiy will be the "owner" of this ship.

The "Akademik Boris Petrov" is equipped with a system that permits small computers located in every laboratory to transmit information to two large computers, which process it, providing a data bank. The two large computers also organize the planning of experiments. These computers were developed specially for research ships at the "Videoton" association (Hungarian People's Republic).

Among other equipment that is unique with respect to capabilities is a multiple-beam sonic depth finder, which was developed by "Hollming" for detailed study of the sea bottom as it is constantly being sounded.

Finnish specialists are taking part in the first cruise along with associates of a number of institutes of the USSR Academy of Sciences. It was not possible to test everything in the shallow Baltic, and the ocean's expanses are necessary for the new deep-water technology to be checked out conclusively.

FTD/SNAP  
CSO: 1865/71

BERING SEA CRUISE PLANS OF RESEARCH SHIP 'VULKANOLOG'

Moscow TRUD in Russian 5 Aug 84 p 2

[Excerpt] Learning how to predict the behavior of volcanoes and ascertaining the mechanism of their eruptions is one of the most important tasks facing the scientists of the Petropavlovsk-Kamchatskiy Institute of Volcanology.

The scientific research ship "Vulkanolog" has been setting out to sea for seven years. It is to work in the Bering Sea this year.

(Two photographs were given showing the "Vulkanolog" on the water and Candidate of Physical-Mathematical Sciences V. Feofilaktov, scientific director of the expedition.)

FTD/SNAP

CSO: 1865/29

## DIVERS WORK FROM BELL AT 200 METERS IN ATLANTIC

Moscow PRAVDA in Russian 27 Sep 84 p 6

[Article by A. Androshin, special correspondent on board the scientific research ship "Vityaz'"]

[Excerpt] Participants in the comprehensive geological-geophysical expedition on board the "Vityaz'" are on a scientific tour of duty lasting many days. Deep dives in the open ocean by Soviet aquanauts Anatoliy Yurchik, Valeriy Antipov, Nikolay Levchenko, Vladimir Tutubalin and Vladimir Podymov, and their Bulgarian colleague Nikola Dukov have been exciting episodes of this expedition.

A depth of 200 meters was reached in a dive to the summit of the submarine mountain Josephine, which is located 400 miles west of Gibraltar.

The aquanauts were kept under constant observation by medical physiologist Valeriy Skudin; Oleg Kuprikov, an experienced diver; Yuriy Dul'skiy and Valentin Tasev, associates of the Institute of Marine Research and Oceanology in Varna; and other specialists belonging to a support group.

"The trip down is difficult and dangerous," said Oleg Skalatskiy, head of the laboratory of manned hyperbaric systems. "Special mixtures must be breathed if great depths are to be reached. Returning to [the surface environment] takes many days, until the prescribed period of decompression has expired. The duration of this period often substantially exceeds that of the period spent on the ocean floor itself. Consequently, descents to deep levels are possible only when the so-called prolonged-stay method is used. Our aquanauts are the ones who introduced this method into oceanologic research practice."

The method which the aquanauts have mastered enabled specialists of the Ministry of the Gas Industry to work at a depth of about 250 meters in the Barents Sea area, for example.

Together with Bulgarian aquanaut Nikola Dukov, Vladimir Tutubalin and Vladimir Podymov distinguished themselves by making an underwater excursion to the summit of the Josephine mountain.



The aquanauts entered a shipboard pressure chamber, in which the pressure gradually rose to the necessary level. Here, in the hold of the "Vityaz'", an underwater elevator-bell was outfitted for the upcoming trip to the ocean floor. Cylinders of this bell had been filled in advance with a breathing mixture. Incidentally, a computer helped to calculate the composition of this mixture for a depth of 200 meters, as well as procedures for descent and subsequent decompression.

The aquanauts returned to the ship in the bell after their assignment had been carried out. After the bell had been connected to the pressure chamber, the aquanauts again went inside the dry compartment, where they stayed until decompression was completed.

(A photograph of the diving bell was given.)

FTD/SNAP  
CSO: 1865/82

## CRYOGENICS APPLICATIONS FOR MHD PROPULSION, OTHER SHIP TECHNOLOGY

Moscow VODNYI TRANSPORT in Russian 18 Aug 84 p 3

[Interview with B. I. Al'shin, head of the Low-temperatures Division, All-Union Scientific Research Institute of Physical-Technical and Radio Measurements, by Anatoliy Ivanovich Kosobrodov, senior engineer of the All-Union Scientific Research Institute of Physical-Technical and Radio Measurements]

[Abstract] The article is an interview with Boris Ivanovich Al'shin, head of the low-temperatures division of the All-Union Scientific Research Institute of Physical-Technical and Radio Measurements. He comments on a new state reference standard of unit of thermal conductivity and its significance for the advancement of cryogenics, and he discusses prospects for cryogenic technology on ships.

Al'shin calls the utilization of superconductivity a highly promising solution to the problem of reducing the size and weight of electric propulsion plants for ships. He observes cryogenic engines could make it possible to have cargo vessels, icebreakers and tankers displacing as much as a million tons. Al'shin also points out that superconductive magnetic systems could make development of a noiseless magnetohydrodynamic propulsion system a reality. He notes that a 2,000-ton-displacement submarine based on such a propulsion mode is being designed abroad. Other types of ship cryogenic equipment that have been proposed are said to include gyroscopes, radar sets and other navigational instruments, small computers with cryotrons, supersensitive pickups, and storage batteries with superconductive windings. Al'shin points out that this technology is still in the development stage, and that much more research and design work will be necessary to perfect it.

In conclusion, Al'shin says that power engineering programs utilizing cryogenic technology are to receive strong support in the immediate future in the USSR. They already are said to include a project for development of superconductive engines for the merchant fleet in the period 1986-1990. Also, work will begin in 1986 on a new icebreaker with a superconductive engine, and on putting 300-megawatt cryogenic turbine generators into experimental operation.

FTD/SNAP  
CSO: 1865/332

## SHIPBOARD AND SATELLITE-AIDED COMMUNICATIONS EQUIPMENT IN EXHIBITION

Riga SOVETSKAYA LATVIYA in Russian 19 Jul 84 p 4

[Article by V. Ryndin]

[Abstract] The article provides information on features of Soviet developments that were being shown in an exhibition, "New Communications Apparatus and Equipment", which opened recently at the USSR Exhibition of National Economic Achievements in Moscow. Particular attention is devoted to equipment intended for the international "KOSPAS-SARSAT" system for locating ships and airplanes in distress and for other satellite-aided communications systems.

This equipment includes an emergency radio buoy, the "KOSPAS-ARB", and a shipboard radio set, the "Standart-A". Among the elements of the "KOSPAS-ARB" are radio beacons operating on a satellite communications channel, and a short-range homing station, which make it possible to shorten search time and expand the detection zone of an object substantially. This buoy is said to ensure precise identification of ships and to provide information on a disaster's coordinates with precision as high as a minute of angle, as well as information on the nature of the disaster. The "KOSPAS-ARB" can also be used by persons working in areas that are remote and difficult to reach. The "Standart-A" is intended for ship-to-shore communications via the geostationary satellites "Inmarsat" and "Gorizont". This set enables ships to communicate with practically any user regardless of weather conditions, it is claimed.

Mention is made also of a shipboard radio set called "Angara". It is produced in two variants: the "Angara-RBI", which is intended for seagoing vessels, and the "Angara RA", which is intended for floating power plants and river vessels of the "Meteor" and other types. The "Angara" is described as a compact, fourth-generation radio set with a memory and a microcomputer, which permits the automatic scanning of eight call channels. The power consumption of the "Angara" is low, and it is capable of transferring automatically to battery power supply if necessary.

A photograph is given showing the "Standart-A" radio set, including its antenna.

FTD/SNAP

CSO: 1865/298

STATUS OF TSUNAMI FORECASTING ASSESSED ON OPENING OF CONFERENCE

Moscow KOMSOMOL'SKAYA PRAVDA in Russian 18 Sep 84 p 4

[Article by A. Zabotin]

[Abstract] The article is an interview with Doctor of Physical-Mathematical Sciences Ye. N. Pelinovskiy, senior science associate of the USSR Academy of Sciences' Institute of Applied Physics, on the occasion of the opening of an All-Union Conference on Tsunamis in Gorkiy. Pelinovskiy is identified as one of the organizers of this conference.

Pelinovskiy assesses progress which has been made in heightening the accuracy of tsunami forecasting in the Soviet Far East. He relates that a unified, automated tsunami observation and warning system is now under development in the USSR for the purpose of improving routine forecasting. This system detects tsunamis with the aid of sensing devices in the open sea. Pelinovskiy himself is working on the problem of long-term forecasting. Mention is made in this connection of a tsunami commission whose members include specialists from many cities. This commission is working on methods of calculating heights and intensities of waves in various coastal areas, as an aid to the construction of buildings with the necessary safety margin. Members of the commission reportedly have learned how to prepare both general forecasts and detailed ones. At the same time, scientists still have not developed methods for forecasting a tsunami's time of occurrence and the specific area that will be affected by it, according to Pelinovskiy.

FTD/SNAP  
CSO: 1865/71

CARIBBEAN AND MEDITERRANEAN OPERATIONS OF MANNED SUBMERSIBLE 'ARGUS'

Moscow PRAVDA in Russian 26 Aug 84 p 6

[Article by A. Androshin, special correspondent on board the scientific research ship "Vityaz'" (Mediterranean Sea)]

[Abstract] The article reports on operations with submersible craft which have been part of an expedition of oceanologists on board the scientific research ships "Vityaz'" and "Rift". During the first stage of this expedition, which has been completed, scientists studied the geological structure of the seabed of the Mediterranean Sea. The manned submersible "Argus" reportedly made 12 dives in the Tyrrhenian Sea. Bulgarian and Italian scientists took part in these dives. At the time of the report, the expedition was headed for the Eastern Atlantic, where observations of the submarine mountain Amper were planned.

A submarine mountain near Sardinia reportedly was the main object of study during the first stage of the cruise. Geological observations of this mountain were made from the "Argus" at depths as great as 500 meters. Commenting on the results of the Tyrrhenian Sea studies, Professor Vyacheslav Yastrebov, who is leading the expedition, related also that about 3,000 photographs of the seabed were made with the aid of an unmanned, remote-controlled craft. Very detailed bathymetric and magnetic charts were made of this area.

A dive made by the "Argus" in the Caribbean Sea is recalled which took place not long before the Mediterranean expedition. The "Argus" was sent down to find the remote-controlled craft after the latter's cable broke. Despite difficult conditions, the craft was located on the seabed and returned to its mother ship with the aid of the "Argus". Vitaliy Bulyga, commander of the "Argus", and pilots Leonid Voronov and Sergey Kholmov took part in this operation.

FTD/SNAP  
CSO: 1865/322



## EFFECT OF INTENSIFICATION OF DECIMETER WIND WAVES IN PETROLEUM SLICK ZONE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 276, No 5, Jun 84  
(manuscript received 24 Nov 83) pp 1243-1246

BRAVO-ZHITOVSKIY, D. M., DOLIN, L. S., YERMAKOV, S. A., ZUYKOVA, E. M.,  
LUCHININ, A. G. and TITOV, V. I., Applied Physics Institute, USSR Academy  
of Sciences, Gor'kiy

[Abstract] The authors investigated the variability of wind waves in slicks and discovered a new effect: intensification of decimeter waves in the zone occupied by a surface-active film. Wind waves were studied using an optical spectral automatic wave recorder during the 3d cruise of the "Vityaz'" in 1982. This instrument made it possible to register the variability of the spatial spectrum of wave slopes in an arbitrarily selected direction of wave vectors  $k$  in the range of wave lengths from a few centimeters to a meter. Emphasis was on observations of variability of the spectrum when passing through a slick about 1 km wide. A slick was intersected by a ship twice with an interval of 3.5 hours; in the first case the wind velocity was 5 m/sec, in the second case--5.5 m/sec. The surface-active film in the slick was quite thin; it could not be observed visually during movement of the ship. As an example, a study was made of the spectral densities at individual wavelengths obtained in the first intersection. It was found that in the centimeter range the spectral density in the slick zone is appreciably less than its background value, whereas in the decimeter range there was an increase in comparison with the background. This dependence of contrast on wavelength was observed repeatedly in the course of the cruise. The article gives a qualitative explanation of the observed effect. Estimates are presented showing that with moderate wind velocities (about 5 m/sec) there is an intensification of wind waves in the presence of a surface-active film in the range of lengths from 20-30 cm to 2-2.5 m. The discovered phenomenon of a spectral inversion of contrast can probably serve as one of the criteria distinguishing slicks caused by surface-active films from anomalies caused by other factors. The term "slick" as a region with reduced intensity of waves must be defined more precisely, giving it a spectral content, and it is possible to speak of smoothing of waves only within certain ranges of its spectrum. Figures 2: references 11: 4 Russian, 7 Western.  
[239-5303]

## POSSIBILITY OF ELECTROMAGNETIC DIAGNOSIS OF EDDIES IN OPEN OCEAN

Kiev VESTNIK AKADEMII NAUK UKRAINSKOY SSR in Ukrainian No 1, Jan 84 pp 3-9

KARNAUSHENKO, M. M., candidate of physical and mathematical sciences, and  
ZHILINA, A. I.

[Abstract] A study of eddies in the open ocean is possible by use of several expeditionary shows with synchronous use of a system of buoy stations; however, this is costly, time consuming and scarcely comprehensive. This article describes an electromagnetic method for the diagnosis of eddies involving the measurement of electric fields in sea water. The authors discuss the intensity of the three-dimensional electric field generated by real eddy formations. Such work has been carried out by specialists of the Marine Hydrophysical Institute, Ukrainian Academy of Sciences, using the results of observations in the POLYMODE test area, making it possible to formulate a series of recommendations on the electromagnetic description of open-ocean eddy formations. After reviewing the very limited literature in this field (such as H. Stommel, "The Theory of the Electric Field Induced in Deep Currents," J. MARINE RES., 7, No 3, pp 386-392, 1948), a theoretical study is presented demonstrating the validity and feasibility of electromagnetic diagnosis of eddies. Eddies of different configuration and special cases are examined. Figure 1 represents electric fields at the ocean surface created by surface and submerged eddies with radii of 50, 100 and 150 km; Fig. 2 shows horizontal electric fields for surface and submerged eddies with radii 50 and 100 km; Fig. 3 shows profiles of the vertical component. For a surface eddy  $E_z \sim 70-100 \mu\text{V/m}$  and  $E_R \sim 150-170 \mu\text{V/m}$ ; for an eddy at a depth of 300 m  $E_z = 60-85 \mu\text{V/m}$  and  $E_R \sim 90-130 \mu\text{V/m}$ . The electric fields generated by real eddies exceed the strength of the background electrotelluric fields in the open ocean by 2-3 orders of magnitude. Figures 3; references 6: 5 Russian, 1 Western.

[98-5303]

UDC: 551.465.553:551.465.431

## EFFECT OF SEA BREEZE ON THERMAL STRUCTURE OF LITTORAL WATERS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKFANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 11 Jun 82) pp 326-328SHELKOVNIKOV, N. K. and TIMOFFEYEV, V. V., Moscow State University,  
Institute of Problems of Mechanics, USSR Academy of Sciences

[Abstract] A study is made of the influence of the sea breeze on changes in the vertical thermal structure of water on the shelf of a nontidal sea. Experimental data were obtained at four stations, seven days each, during the summertime. Continuous vertical temperature profiles were measured

at these stations each half hour, and the speed and direction of current and wind were measured. The breeze was found to influence the field of current speeds, producing diurnal periodicity. The current speed vector was broken down into two components - parallel and perpendicular to the shore. The perpendicular component showed the greatest diurnal change. The depth of the seasonal thermocline also varied on a daily cycle. The position of the thermocline coincides with the bottom of the layer in which the drift current is under the influence of the breeze. No inertial currents were observed in the area. The daily changes in vertical thermal structure were related to changes in the direction of drift transfer of water in the upper layer under the influence of the sea breeze. Figures 3; references 4: 2 Russian, 2 Western.  
[160-6508]

UDC: 550.373

#### INFLUENCE OF ELECTROSTRATIFICATION OF SEA ON DRIFT AND BAROGRADIENT CURRENT ELECTROMAGNETIC FIELDS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 3 May 83) pp 261-265

FONAREV, G. A., FIDELIS, V. V. and MIKHAYLOV, Yu. M., Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences

[Abstract] The purpose of this work was to estimate the influence of heterogeneous distribution of conductivity in a water layer on the electromagnetic field of a current. Induction of an electromagnetic field by drift and barogradient currents in an electrostratified sea of finite depth was studied. The results demonstrate the vertical profile of the horizontal components of the induced magnetic field as both drift and gradient components in the velocity of a current or a homogeneous sea and for the case of maximum possible electrostratification. The gradient component of the induced magnetic field increases with increasing electrostratification throughout the cross section with elevation of the maximum in the friction layer along the bottom. Figures 2; references 9: 8 Russian, 1 Western.  
[150-6508]

GEOMORPHOLOGICAL AND LITHODYNAMIC CRITERIA FOR SEARCH FOR ACCUMULATIONS  
OF HEAVY MINERALS ON SHELF

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian  
No 3, May-Jun 84 (manuscript received 15 Jun 82) pp 50-56

GRIGOR'YEV, M. N. and IGANATOV, Ye. I.

[Abstract] Studies were performed in 1978-1980 on the central Primorsk shelf. Bottom samples were taken at a depth of 30-40 m at intervals of 5 m and subjected to particle-size distribution analysis. The materials were compared with the data of other researchers for the entire shelf. The banks in this area are largely abrasional and abrasional-denudational types. A table presents geomorphological criteria to govern the search for useful minerals on the shelf in this area on the basis of the studies performed. Factors studied include morphology of continental area and shore contour, presence of contemporary rivers and ancient beds, aspects of the history of development of relief, abrasive effects on bottom and shore and nature of the shelf. Lithodynamic criteria for accumulation of heavy minerals on the shelf are presented in a second table. These lithodynamic factors are a very important element in the study of promising areas of placer formation in this area. References: 13 Russian.  
[174-6508]

UDC: 551.465.7+551.511

MEAN ENTROPY FLOW THROUGH OCEAN SURFACE

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 5, Apr 84  
(manuscript received 3 May 83) pp 1015-1018

KIL'MATOV, T. R., Pacific Institute of Oceanography, Far Eastern Scientific Center, USSR Academy of Sciences, Vladivostok

[Abstract] An equation is derived for computation of the change in entropy due to the exchange of heat and mass at the ocean surface based on meteorological observations. Sea water is considered a solution with salt, the single dissolved substance. The results of calculation for the ocean are studied for each 5° zonal band and it is noted that heat enters the ocean at a higher temperature than that at which it is transferred from the ocean to the atmosphere. This flux thus compensates for the internal process of temperature field equilibration within the ocean. A similar picture is observed for the water balance. Water enters the ocean at reduced salinity and is carried from it at higher salinity. The work of the wind at the ocean surface per unit area per unit time is estimated in order to compare the thermohaline and wind effects on the ocean. Figure 1; references 9: 8 Russian, 1 Western.  
[156-6508]

## ENERGY ACTIVE AREAS OF OCEAN

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 4, Apr 84  
(manuscript received 27 Jul 83) pp 1018-1021

LAPPO, S. S., GULEV, S. K., METAL'NIKOV, A. P., ROZHDESTVENSKIY, A. Ye.,  
SOKOLOV, V. A., VOLKOVA, G. P., KOPEYKINA, T. N., REVA, Yu. A.,  
TIKHONOV, V. A. and SENENOV, M. V., State Oceanographic Institute, Moscow

[Abstract] An energy active area in the ocean refers to a region (focus) where the intensity of energy exchange between the atmosphere and the ocean is three to five times greater than the background levels. A general map of the energy active areas of the world ocean is presented, obtained by a new method which the authors have developed, based on analysis of variation between characteristics in the upper layer of the ocean such as water temperature and saturation moisture content in the adjacent layer of the atmosphere over an annual cycle. The equation form closed trajectories or loops over the course of a year. A quantitative check of the method suggested shows good agreement with estimates produced by other methods. Calculations were based on mean monthly values of hydrometeorological elements at the points of intersection of a  $10^\circ$  grid throughout the ocean. The greatest phase differences in annual temperature fluctuations are characteristic of the tropical energy active area, particularly the Malayan Archipelago. Analysis shows that the contribution of the integral heat exchange of long period climatic processes predominates in the equatorial-tropical areas and in the polar regions. In the middle latitudes the location of elevated climatic energy activity is similar to that of the energy active areas in the seasonal cycle. Figure 1; references 11: 10 Russian, 1 Western.  
[156-6508]

UDC: 551.263.036

## SOME METHODOLOGICAL ASPECTS OF STUDY OF LAYER ASSOCIATIONS IN CONTINENTS AND OCEANS

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 26 Sep 83) pp 106-109

KIRILLOVA, G. L., Institute of Tectonics and Geophysics, Far Eastern  
Scientific Center, USSR Academy of Sciences, Khabarovsk

[Abstract] Formation analysis is increasingly used in oceanographic studies. Most classifications of oceanic sedimentary formations are based on the types of morphological structures and the conditions of their formation. This leads to the problem of the hierarchy of the subdivision of the formation levels. Most researchers relate systems of deposits making up large



geomorphological elements such as shelves, continental slopes and ocean beds to formations. Subformations are smaller units of the underwater relief such as littorals, the shallow and deep shelf. Microformations and facies are still smaller geomorphological elements. Achievements in the geological and geophysical study of the seas and oceans have made it possible to correlate associations of layers of various ranks in the continents and oceans. There are three ranks of layer associations both on the continent and on the ocean floor. The primary unit of seisostratigraphic analysis is the sedimentary system. These systems were laid down over 1 to 10 million years, vary in thickness from a few centimeters to (more usually) tens or hundreds of meters, and are traced over tens or hundreds of kilometers across the strike of a basin and still further in the direction of strike. Lithofacies are elements of sedimentary systems. Sedimentary systems formed at the same time can be combined into tracks or lateral rows of systems. Correlation of geological bodies in transitional zones between continents and oceans is a pressing task of today. References: 15 Russian.  
[167-6508]

UDC: 551.46

#### ROLE OF BACTERIOPLANKTON IN PRODUCTIVITY AND CYCLING OF ORGANIC MATTER IN SOUTHEAST PACIFIC

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 6, Apr 84  
(manuscript received 13 Jul 83) pp 1499-1503

SOROKIN, Yu. I. and MAMAYEVA, T. I., Southern Division, Institute of Oceanography imeni P. P. Shirshov, USSR Academy of Sciences, Gelendzhik, Krasnodar Kray

[Abstract] During the 34th voyage of the research vessel "Akademik Kurchatov" specialists studied the functional role of bacterioplankton as a component of the pelagic southeast Pacific. Number, biomass and production of bacterioplankton were determined in five main sections beginning at the equator and ending in the subtropical convergence. The quantity of organic matter available and its turnover rate were determined at a number of points. Samples were taken from 12 to 15 depth levels down to 200 m in 140-liter plastic bathometers. Depth levels were selected after preliminary probing of the vertical distribution of temperature, chlorophyll and bioluminescence. Over 400 samples were analyzed in all. The results of the determination are presented separately for the upper layer of the water mass including the upper mixing layer and the thermocline layer and for the lower layer down to 200 m depth. In the oligotrophic Northern Trades area the population, biomass and production of bacterioplankton were an order of magnitude lower than in the mesotrophic southeast Pacific in areas of active hydrodynamics. In the area of the equatorial frontal separation between the Galapagos and the equator the population, biomass and production of bacterioplankton were approximately the same as in the mesotrophic waters of the ocean. Figures 3; references 10: 6 Russian, 4 Western.  
[186-6508]

## RESULTS OF GEOCHEMICAL STUDY OF BAY SEPARATED FROM SEA IN RELATION TO PRESENT-DAY KARA-BOGAZ-GOL PROBLEM

Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO-TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 1, 1984 (manuscript received 17 Nov 83) pp 110-112

GAVRILOVA, L. A., Moscow State University imeni M. V. Lomonosov

[Abstract] Kara-Bogaz-Gol bay is a huge depression 31 m below sea level separated from the Caspian Sea by a sand formation. The bay was connected to the Caspian Sea by a strait until March 1980, at which time this strait closed. The hydrological and hydrochemical characteristics of the bay have changed significantly during its history as an isolated basin. A table presents changes in the chemical composition of the water in the bay between 1978 and 1982. In 1978 the salt content of the bay was essentially astrakhanite; presently in summer it is epsomite. In winter it is halite, indicating desulfurization of the water. The brine has been significantly diluted, primarily due to the heavy rains of 1982-1983 and reduced evaporation resulting from lower temperatures. Precipitation of potassium salts is beginning in the bay. Figures 2; references: 3 Russian. [196-6508]

UDC: 551.465.52

## FORMATION OF DEEP EASTERN MEDITERRANEAN WATERS IN ADRIATIC

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 3, Mar 84 (manuscript received 14 Jul 83) pp 744-749

OVCHINNIKOV, I. M., ZATS, V. I., KRIVOSHEYA, V. G. and UDODOV, A. I., Southern Division, Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences, Gelendzhik; Institute of Biology of the Southern Seas imeni A. O. Kovalevskiy, USSR Academy of Sciences, Sevastopol

[Abstract] Soviet and foreign work on the question of formation of the deep water structures of the eastern Mediterranean in the Adriatic is described. In March of 1983 the research vessel "Professor Vodyanitskiy" made a hydrological survey of the entire Adriatic, revealing convective processes in the sea. The weather conditions and results of observations during this 10-day period are described. As a result of the studies, for the first time the entire process of the winter convective movements was demonstrated. Most of the deep Adriatic waters are formed as a result of convection developing down to great depths in the center of the southern cyclonic circulation during the period of greatest cooling of the surface layer (late February-early March). During this time, these waters are actively carried through the Strait of Otranto and serve as the main source for the deep water mass of the entire eastern Mediterranean. Figure 1; references 13: 3 Russian, 10 Western. [181-6508]

## CASPIAN SEA WAVE FIELDS WITH MODERATE WIND SPEEDS IN PREVAILING DIRECTIONS

Baku IZVESTIYA AKADEMII NAUK AZERBAYDZHANSKOY SSR: SERIYA NAUKI O ZEMLE  
in Russian No 3, 1984 pp 137-143

ABAKAROV, M. I., BADALOVA, A. N., GADZHIYEV, Ya. Z. and UTURGAURI, L. G.

[Abstract] Calculations are made to obtain information on the modal characteristics of wave action in the entire Caspian Sea with the wind from the prevailing directions. The basis for calculation of wave action in the deep-water area is equations describing the variation in mean wave periods and heights as a function of wind speed and time or fetch. The variations are expressed as exponential functions using the methods of the theory of dimensionalities and mathematical statistics. Observational data are used as the initial inputs to construct mean wind speed fields for the frequently observed northerly, northwesterly and southerly, southeasterly wind directions. Eight maps are constructed on the basis of the calculations. Figures 3; references: 5 Russian.  
[155-6508]

## DISLOCATIONS AND CRYOLITHOGENESIS IN PLEISTOCENE IN NORTHERN EURASIA

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian  
No 3, May-Jun 84 (manuscript received 25 Oct 83) pp 3-9

POPOV, A. I.

[Abstract] Plicative dislocations form holes of various sizes and are traced over hundreds of meters both vertically and along the strike. The genesis of plicative dislocations is underwater slipping of uncompacted sediment. The slip deformations in contemporary sediments reach significant size, comparable to Pleistocene dislocations described in the literature. Observational data indicate regular displacement of ice formations in dislocated Pleistocene sand and clay deposits. The relationships of dislocations and ice indicate syngenetic deformation and ice formation. It is concluded that the distribution of ice depends directly on the process of dislocation itself, that dislocation of sediment stimulates ice formation. Mechanisms by which supercooled sediments can lose equilibrium and undergo simultaneous dislocation and ice formation are discussed. A dislocated previously thixotropic sediment is firmly armored by ice cement which follows the shape of the dislocation itself and prevents a return to the previous coagulated structure. References: 15 Russian.  
[174-6508]

## TERRESTRIAL GEOPHYSICS

### EARTHQUAKES AND TECTONICS OF PACIFIC OCEAN MARGINS

Moscow PRIRODA in Russian No 3, Mar 84 pp 27-33

[Article by L. M. Balakina]

[Text]

Biographical data concerning the author:  
Lyudmila Mikhaylovna Balakina, candidate  
of physical and mathematical sciences,  
senior scientific specialist in the Seis-  
mology Section, Physics of the Earth Inst-  
itute imeni O. Yu. Shmidt, USSR Academy of  
Sciences. Engaged in study of earthquakes  
by seismic methods.

The margins of the Pacific Ocean have long attracted the attention of many geologists and geophysicists from different countries of the world since at the present time the most intensive tectonic movements on the earth are occurring here. They are leading to the formation of special geological structures -- island arcs, constituting arcuate chains of islands bounded on their external, convex side by abyssal oceanic trenches. The overwhelming number of island arcs on the earth are situated in the Pacific Ocean, on its northern and western margins. On the eastern margin of the Pacific Ocean there are no real island arcs. They are replaced here by the geological structures of the ridges of the Central American cordilleras and the South American Andes, which are bounded by abyssal trenches. In most cases the outer sides of the island arcs with the trenches are turned toward the Pacific Ocean, whereas so-called "rear" basins are situated on their inner sides.

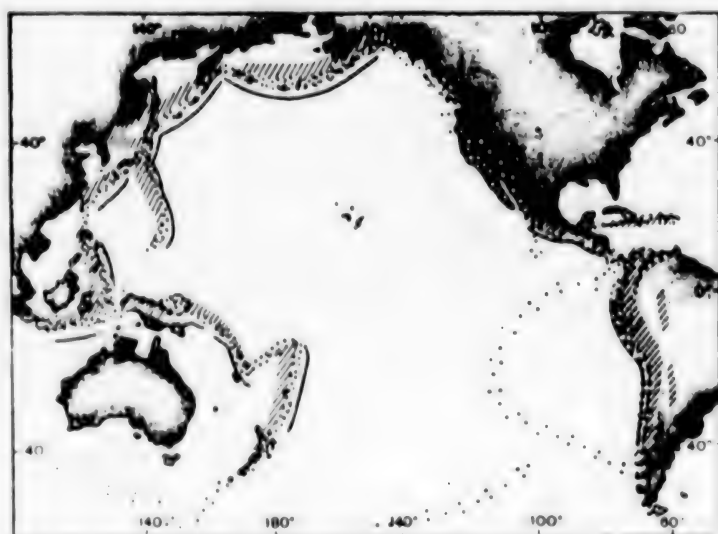
The high intensity of the tectonic movements causes a high seismic activity on the Pacific Ocean periphery. The Pacific Ocean seismic belt is situated here. More than 80% of all the world's earthquakes with foci in the lithosphere and in the upper mantle, as deep as 600-700 km, occur here\*. The hypocenters of earthquakes in the upper mantle, below 70 km, are not arranged randomly, but are grouped into relatively narrow layers, plunging in a sloping direction from the abyssal trenches under the islands\*\*. Such layers of hypocenters have been given the name focal zones, from the word "focus," being a synonym for hypocenter.

\* A focus is a sector of a discontinuity along which there is a jumplike displacement of an adjacent block of rocks.




\*\* A hypocenter is the initial point of rupturing at the earthquake focus. The projection of the hypocenter onto the earth's surface is the earthquake epicenter.



There are different points of view concerning the nature of focal zones and the nature of tectonic processes in the island arcs. According to some concepts focal zones are gigantic faults penetrating for hundreds of kilometers into the upper mantle and the earthquakes in them are caused by sharp displacements along individual sectors of these slanting faults. According to other concepts they correspond to zones of contact of regions of the mantle with different properties. Some researchers assume that the island arcs are in a state of transverse dilatation and are gradually sinking. In this case earthquakes are generated by the subsidence of blocks along fractures. According to other points of view, the island arcs, on the contrary, are in a state of transverse compression.



Regions of earthquake occurrence:

-  surface
-  intermediate [at depths from 70 to 300 km] and deep [at depths greater than 300 km]
-  axes of trenches

Map of manifestation of earthquakes in Pacific Ocean [the different density of points schematically reflects the different frequency of earthquake occurrence].

During recent years an explanation of the nature of focal zones on the basis of plate tectonics has gained wide acceptance. Within the framework of this hypothesis it is customary to assume that they arise as a result of plunging (subduction) of plates of the oceanic lithosphere into the mantle under the island arcs; in this case in the upper parts of the lithosphere over the focal zone there is formation of extended rupturings or thrusts, gently dipping from the trenches in the direction of the rear basins, along which surface earthquakes develop, including very serious earthquakes. However, earthquakes in the focal zones proper are either a result of slippage of the upper boundary of a plunging lithospheric plate relative to the above-lying mantle or a result of deformation of the plate itself in the process of its plunging.

It is quite difficult to determine the nature of tectonic processes in the marginal regions of the Pacific Ocean because the regions of the most intensive tectonic movements here are hidden beneath the water. Moreover, a reliable knowledge of the essence of processes in the island arcs is necessary for a correct






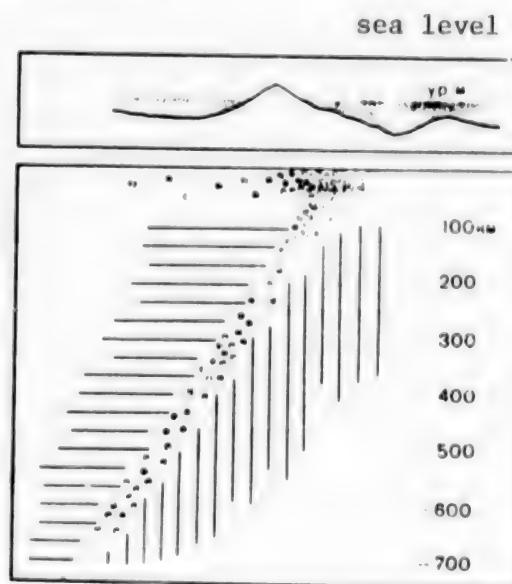
understanding of the overall tectonic development of the earth. One of the ways to clarify this question and to check existing hypotheses is to use the results of investigation of the conditions for the occurrence of earthquakes carried out recently by Soviet and foreign seismologists.

### Spatial Distribution of Earthquake Foci

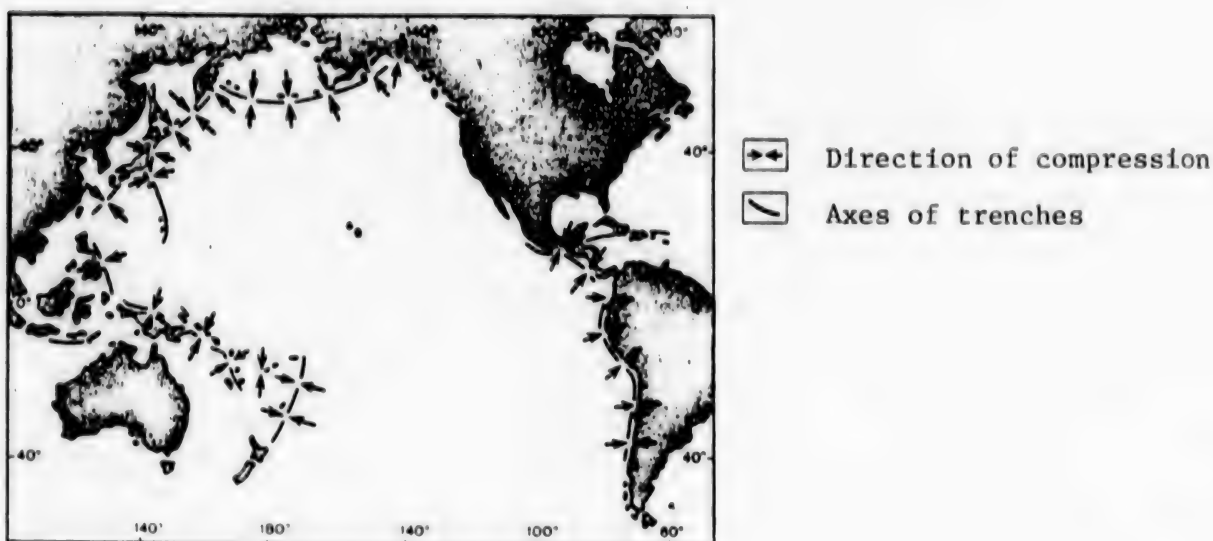
We recall that the formation of geological structures, including island arcs, occurs as a result of tectonic movements developing unidirectionally over a long period of time. This results in the formation of fractures\* in the earth's body: surfaces of differentiated movements of masses bounding the corresponding geological structures. The slow tectonic movements from time to time alternate with rapid jumplike movements along the fractures, leading to earthquakes. The magnitude of the earthquake (the extent of the focus releasing energy) is dependent on the type and extent of the forming geological structures and the fractures bounding them, whereas the frequency of occurrence of earthquakes is dependent on the intensity of tectonic movements. The movement of masses along a fault at the earthquake focus reflects the direction of tectonic movements in the particular region and exerts an influence on the formation of the corresponding geological structure.

Diagram of positioning of earthquake hypocenters in vertical section perpendicular to island arc. At top -- section through island arc, vertical scale greater than horizontal scale.

-  Hypocenters
-  Upper mantle under rear basin
-  Oceanic upper mantle



\* Among the tectonic dislocations we can distinguish: fault -- a dislocation along whose surface the above-lying masses (the masses of the upper side of the fault) move downward; upthrust -- a dislocation tilted to the horizon at an angle greater than  $45^\circ$ , along whose surface the masses of the upper side move upward; overthrust -- a gently sloping fracture along whose surface there is an overthrusting of the masses of the upper side; displacement -- a fracture with a relative movement of adjacent blocks along its strike. Displacements along faults are frequently combined with movements along the dip of the interface, forming upthrust displacements, strike-slip faults and overthrust displacements.



Map of orientation of compressions in lithosphere of inner (island and continental) slopes of Pacific Ocean trenches.

The instrumental investigation of earthquakes is based on an analysis of seismic waves (longitudinal, transverse and surface), arising in the earth during the jumplike movement of masses along a dislocation at an earthquake focus. Seismic waves are registered by special instruments (seismographs) installed at seismic stations in different regions of the earth. On the basis of the arrival time of seismic oscillations, using definite procedures, it is possible to determine the location of an earthquake hypocenter. Large earthquakes with foci in the lithosphere are usually accompanied over the course of some period of time by numerous weaker tremors (aftershocks) arising in the neighborhood of the dislocation along which the displacement of masses occurred at the time of the large earthquake. The spatial distribution of the hypocenters of aftershocks can be used in judging the approximate extent and orientation of the foci of large earthquakes.

A considerable volume of data has now been accumulated on the spatial distribution of earthquake hypocenters and foci along the margins of the Pacific Ocean. It was found that the greatest number of hypocenters of earthquakes, including the largest, arising in the lithosphere (to a depth of 70 km), is concentrated under the island slopes of trenches\*. However, beneath the islands themselves, and the rear (landward) basins, and also under the oceanic slopes of the trenches, there is a relatively small number of hypocenters in the lithosphere.

Tectonic movements leading to earthquakes in the island arcs are manifested in the peculiarities of their geomorphology. The island slopes of the trenches are characterized by underwater rises of different longitudinal extent and degree of development parallel to the arc. The rises are separated by longitudinal downwarps. The highest rises form underwater ridges parallel to the

\* The slope of the abyssal trench between the chain of islands and the axis of the trench; its width is different in different arcs and can attain 100-200 km, sometimes more. The opposite slope of the trench is called the oceanic slope.

arc (as, for example, the Vityaz' Ridge in the Kuril arc) and can lead to appearance of double island arcs (for example, the Greater and Lesser Kuril Islands). In addition to these principal morphological features, in the island slopes of trenches there are numerous small rises (horsts) and depressions (grabens) with different orientations. On the basis of geomorphological and geophysical data in the island arcs it is possible to discriminate longitudinal dislocations of different extent, together with which there are faults cutting the island arc at right angles.

The foci of major earthquakes in the lithosphere (the fractures responsible for them) in most cases extend the same as the rises and downwarps, along the island arc. The foci of the next major earthquakes are situated in the intervals between the foci of the preceding tremors. In different island arcs the maximum dimensions of the mobile blocks making up the island slopes of the trenches and the rates of the tectonic movements are different. This is reflected in the differences in the maximum earthquakes for them and the frequency of their occurrence.

As was already noted at the beginning of the article, the hypocenters of earthquakes occurring in the mantle, deeper than the upper 70-km layer, are grouped in relatively narrow (with a width of about 50 km) focal zones. The form of the focal zones is different in the different island arcs. Their slope to the horizon and extent in depth are different, as are the distribution and frequency of the tremors at different depths. The form of the focal zones in vertical section can vary from a linear strip to a curving strip with a change in the angle of inclination with depth. The limiting depth, inclination and form of the focal zone may vary not only from one island arc to another, but also along the strike of one and the same arc.

The minimum angles of inclination of focal zones are 20-25°; the maximum angles are 80°. Their limiting extent in depth varies from 200-250 km to 600-700 km. For the totality of all island arcs in the Pacific Ocean K. Abe and H. Kanamori\* note some increase in the number of earthquakes with hypocenters at depths of 350-400 and 600-650 km (where, possibly, regions of phase transitions in the mantle are situated) and a decrease in the number of hypocenters in the region of depths of about 200 km.

Data on the distribution of earthquake hypocenters in the focal zones are inadequate for having some idea concerning tectonic processes on the Pacific Ocean margins. It is necessary to know the orientation of extended fractures and the directions of movements at the foci of earthquakes in the focal zones. These parameters of earthquakes, in seismology receiving the name "focal mechanism," are determined from the displacements in the longitudinal and transverse waves registered by many seismic stations by means of special methods which will not be discussed here.

#### Focal Mechanism

Soviet and foreign authors have studied the focal mechanism of many earthquakes from the Pacific Ocean island arc regions. Our analysis of the results of these studies indicated the following:\*\*

\* Abe, K., Kanamori, H., J. GEOPHYS. RES., Vol 84, No 87, p 3589, 1979.

\*\* Balakina, L. M., IZV. AN SSSR: FIZIKA ZEMLI, No 4, p 43, 1979; No 5, p 16, 1979; No 8, p 13, 1981.

The regions of the lithosphere to a depth of 70 km situated beneath the island slopes of the trenches are characterized by subhorizontal transverse compression. Major earthquakes with foci in these regions can be caused either by the uplifting of major blocks along steep fractures (upthrusts) of the same orientation or by movements of masses along gently dipping fractures. The orientation relative to the island arc for such gently dipping fractures and the directions of the movements in them are different for different earthquakes and in general do not correspond to the gently sloping overthrusts which should exist in accordance with the subduction scheme. Seismic data instead indicate that in the tectonics of the island slopes of trenches an important role is played precisely by subvertical movements (uplifts) of lithospheric blocks along steep upthrusts.

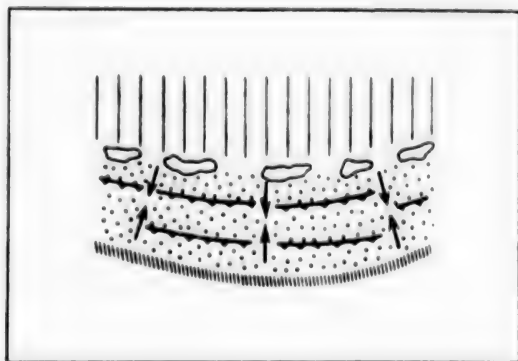





Diagram of horizontal arrangement of compression regions and manifestations of upthrusts in island arc-trench system.

Island 

Directions of compressions 

Rear basin 

Trench axis 

Lithospheric compression region 

Longitudinal upthrusts 

Upthrusts at earthquake foci manifest a distinct regularity in their orientation, extending along the island arcs and dipping in the direction of the trench. In the case of the largest earthquakes the extent of such fractures can attain several hundreds of kilometers in length and several tens of kilometers in depth. The vertical deformations of the ocean floor arising during the displacement of blocks along steep upthrusts explain well the conditions for the generation of tsunami waves during earthquakes and also the presence of horst-anticlinal uplifts in the island slopes of trenches. Some earthquakes in the lithosphere of the island arcs are caused by displacements along fractures cutting arcs. Displacement fractures can delimit blocks moving along longitudinal upthrusts. Weaker earthquakes with a small extent of the foci, reflecting movements along fractures of smaller blocks, are characterized by a greater diversity in the orientations of upthrust-overthrust and displacement fractures at their foci.

A different type of stresses and fractures is manifested during earthquakes arising under the oceanic slopes of trenches. According to data from the American seismologist W. Stauder\* and some other researchers, these regions of the lithosphere are characterized instead by transverse dilatation and the earthquakes are caused by the down-dropping of blocks along longitudinally oriented faults. The predominance of uplifts in the lithosphere of the island

\* Stauder, W., J. GEOPHYS. RES., Vol 73, No 12, p 3847, 1968.



slopes of the trenches and at the same time subsidence in their oceanic slopes can lead to a gradual displacement of the island arc-trench system in the direction of the ocean. The existence of double island arcs may be a reflection of such a process. The few investigations of the infrequent earthquakes arising in the lithosphere of the rear regions of island arcs indicate that possibly some of them are characterized by subhorizontal compression, whereas others are characterized by dilatation.

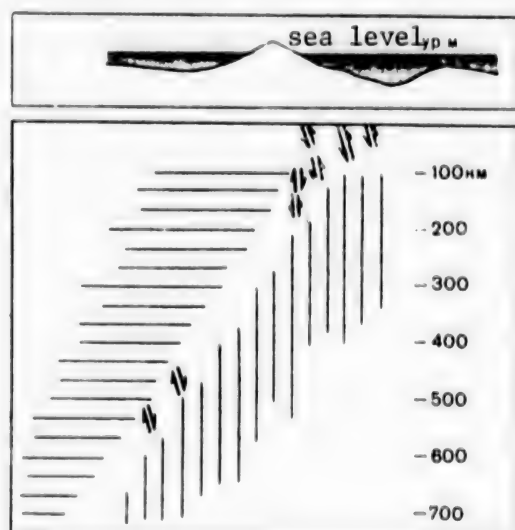






Diagram of manifestation of steep fractures in vertical section perpendicular to strike of northern part of Kuril island arc.

-  Upthrusts
-  Faults
-  Upper mantle under rear basin
-  Oceanic upper mantle

In the focal zones below 70 km the orientation of the fractures, movements and stresses at earthquake foci becomes more complex and nonuniform. In some cases it is similar to the pattern in the upper part of the focal zones, whereas in others it differs substantially from it. The orientation of the fractures and stresses at the foci of intermediate (depths 70-300 km) and deep (more than 300 km) earthquakes may vary not only from one island arc to another, but also within the limits of a single arc, along its strike, and with movement from the intermediate to the deep parts. It should be emphasized, in particular, that within the limits of all depths at earthquake foci there are no fractures having a dip along slant focal zones. All the possible fractures cut across the focal zone.

In some focal zones in their deep parts earthquakes are caused primarily by faults during subhorizontal transverse dilatation. The focal mechanism of such earthquakes is opposite the mechanism of earthquake foci in the lithosphere of the island slopes of trenches. Faults are sometimes also noted in the intermediate parts of the focal zones together with a predominance of upthrusts and overthrusts there.

The results of some studies show that at the foci of deep earthquakes, in addition to shearing movements, there can be volumetric movements which are possibly caused by phase transformations of matter at the corresponding depths.

The American seismologists B. Isacks and P. Molnar<sup>\*</sup>, proceeding on the subduction hypothesis, postulate that at the earthquake foci along the margins of

<sup>\*</sup>B. Isacks and P. Molnar, REV. GEOPHYS. AND SPACE PHYS., Vol 9, No 1, p 103, 1971.



the Pacific Ocean one of the stresses -- compression or dilatation -- is oriented along the dip of the sloping focal layers. In their opinion this is attributable to the fact that the lithospheric plate at the time of its plunging, experiencing the influence of intrinsic gravity and mantle resistance, will be in a state of either longitudinal dilatation or longitudinal compression, depending on the depth of submergence and the properties of the surrounding mantle. However, the existence of different types of fractures and displacements in the intermediate and deep parts of the focal zones at earthquake foci, as well as the diversity of their orientations, agrees poorly with the stressed state scheme postulated by American seismologists.

Everything stated above concerning the distribution of earthquake hypocenters and focal mechanisms can be illustrated in the example of the focal zone of the Kuril island arc, one of those which has been best studied. In the lithosphere of the entire Kuril arc the focal mechanism of large earthquakes is characterized by special features characteristic of island arcs, as was mentioned above. However, the focal zones at depths below 70 km in the northern and southern segments of the Kuril arc differ somewhat both in their structure and with respect to the type of earthquake focal mechanism.

In the northern part of the Kuril arc the focal zone plunges in the direction of the Sea of Okhotsk at an angle of about  $50^\circ$  to a depth of 600-650 km, whereas in the southern part, at an angle of  $35-40^\circ$  to a depth not greater than 400-450 km. In the focal zone of the northern segment of the arc at depths of 70-150 km most of the earthquakes are attributable to upthrusts of the same orientation as the earthquakes in the lithosphere of the island slope of the trench. But at the same time, at these depths here there are earthquakes caused by faults. In the lower part of the focal zone in the Northern Kurils the fault displacements at the earthquake foci become predominant. In the extent of the entire northern segment of the focal zone, from the surface to its lower boundary (600-650 km), there are subvertical fractures extending along the island arc, maintaining a stable pattern of orientation. All the possible fractures at the earthquake foci in the direction of their dip cut the sloping focal zone.

In the southern part of the Kuril arc, more frequently than in the northern part, in addition to longitudinal fractures, at the earthquake foci there are steep fractures cutting the island arc. In their nature they are predominantly upthrust displacements and displacements. Within the limits of the lithosphere such fractures are detected, in particular, in the region of joining of the Kuril arc and Hokkaido and along the northeast margin of the Lesser Kuril arc. At the earthquake foci cutting upthrust displacements and displacements are also manifested in intermediate and deep regions of the focal zone of the southern part of the Kuril arc; the stability of the predominant orientation of the fractures decreases with depth. In contrast to the northern half of the Kuril arc, in the focal zone here it is less common to observe earthquakes with fault displacements.

#### Some Conclusions

It can therefore be said that the results of investigation of the earthquakes along the margins of the Pacific Ocean still do not afford any possibility for

formulating any full and adequately substantiated idea concerning tectonic processes responsible for the existence of island arcs and focal zones. This requires further detailed investigations of earthquakes in each of the island arcs. However, the seismic data which have been obtained even now make it possible to draw the following conclusions concerning existing points of view concerning tectonic processes in the island arcs of the Pacific Ocean.

Focal zones cannot be regarded as gigantic planetary faults penetrating for hundreds of kilometers into the mantle. At the foci of earthquakes occurring at all depths in these zones there are no fractures oriented along sloping focal layers.

Seismic data fail to confirm the idea that longitudinal fractures in the lithosphere of the island slopes of trenches are faults reflecting the postulated process of subsidence of island arcs. The existence of faults and conditions of subhorizontal dilatation in the lithosphere are noted on the basis of seismic data for the oceanic slopes of trenches.

In validating the existence of subduction of the oceanic lithosphere along the margins of the Pacific Ocean it is common to cite the results of investigation of Pacific Ocean earthquakes. However, their analysis indicates that they cannot serve as demonstration of this process. For example, seismic data do not unambiguously indicate that large earthquakes in the lithosphere of the island arcs are caused by gently sloping overthrusts, as is stipulated in subduction schemes. The appearance of subhorizontal transverse compressions in the lithosphere of the island slopes of trenches may not be caused by subduction, but by the predominance of unidirectional ascending movements of masses in this region. Fractures in focal zones below 70 km, as well as the complex distribution of stresses there, also cannot serve as a validation of subduction.

The results of investigation of the focal mechanism of Pacific Ocean earthquakes give basis for assuming that in the tectonics of the lithosphere situated under the island slopes of the trenches the leading role is played by subvertical upthrust movements (uplifts of blocks) under conditions of subhorizontal transverse compression. The predominance of subvertical movements possibly also persists in the focal zones below 70 km, but there they in general are less regular and may be either ascending or descending. Uplifting of the lithospheric blocks in the island slopes of trenches, together with the subsidence of blocks in the lithosphere of oceanic slopes, may lead to the gradual displacement of an island arc in the direction of the ocean.

The presently accumulated results of investigations of the focal mechanisms of earthquakes of the island arcs suggest that earthquakes in the focal zones are not caused by the existence of any uniform system of stresses or the existence of superdeep planetary faults, but as noted by Yu. M. Pushcharovskiy\*,

---

\* Yu. M. Pushcharovskiy, DOKLADY AN SSSR, Vol 241, No 4, p 903, 1978.

by processes in the zone of contact of mantle regions with different properties with which the focal zone coincides. These processes possibly are related to the differentiation of matter in the mantle in the margins of the Pacific Ocean, leading, in particular, to its ascending and descending movements, accompanied by phase transitions.

COPYRIGHT: Izdatel'stvo "Nauka", Moskva "Priroda", 1984

5303

CSO: 1865/228

## SOME TRENDS IN THE MODERN EARTH SCIENCES

Moscow PRIRODA in Russian No 6, Jun 84 pp 3-17

[Article by V. V. Belousov]

[Text] Introduction by Yu. M. Pushcharovskiy, corresponding member, USSR Academy of Sciences.

The new geodynamic concept, the tectonics of lithospheric plates, appearing during the last quarter-century, has played a significant role in the development of modern geology. However, it must be noted that many of our theoreticians are not satisfied or are not entirely satisfied with this concept and are formulating their own models of tectogenesis on the earth. Most common among these models are those taking into account major horizontal movements of rock masses in the upper geospheres. But there are also models based on data on vertical movements in the earth's crust and mantle. Precisely such ideas are being developed by V. V. Belousov, whose article contains a critique of the fundamental principles of plate tectonics. The existence of different points of view concerning problems in geodynamics is entirely natural because these matters in natural science relate, if one can express it so, to the category of questions of a higher complexity. One of the reasons for this is the irreproducibility of the processes, especially in their highly complex combination, in an experiment. Without question the discussion of these complex matters from different points of view is useful because in the long run it will bring us closer to a correct comprehension of matters.

\*\*\*

Already in antiquity man pondered as to why earthquakes occur and why volcanoes erupt. For a long time he sought an answer to these questions in myths about underground winds and gods who dwell beneath the earth's surface. During the Middle Ages the Christian church for many centuries by means of its iron-clad dogma hindered any effort to penetrate into the earth's history, instructing that the earth was created in a few days and that from the "creation of the world" the only major event on the earth was the "universal flood."

A break occurred in the 16th-17th centuries when restless people of that time began to need metal for the forging of weapons and the minting of coins. In order to find and extract metal it was necessary to have information on the structure of at least the uppermost layers of the earth's crust. The first ideas in the field of structural geology were obtained in the process. Most important among these ideas were those relating to the geometry of ore veins, about how outcrops of ore veins are projected onto the uneven surface of the earth.

With respect to more general questions concerning movements and development of the earth's crust, they began to take on a scientific look only in the 18th century in the work of M. V. Lomonosov and the Scotch scientist J. Hutton. The first question which was then formulated dealt with the origin of mountain ranges, this disruption of the normal level of the earth's surface, a result of its warping by some internal forces. And since at least amidst some mountains there are volcanoes, the "internal heat in the earth's womb" began to be seen as these internal forces. So it was expressed by Lomonosov in his well-known work "On the Earth's Layers."

The laws of bedding of layers in mountain ranges were not yet known. It was only known that the layers in the mountains are not bedded horizontally, as on plains, but are slanted at different angles. Writers spoke of "disorder" in the bedding of the layers and attributed this disorder to the breaking of the layers during the rising of the mountains.

But then at the beginning of the 19th century the stratigraphic significance of fossilized organic remains was discovered and it became possible to determine the relative age of the layers, if only they were visible in different shows at any distance from one another. And then it was discovered that the layers in mountains are bent into folds. This was a discovery of enormous importance. It gave rise to doubts as to the correctness of concepts concerning mountain ranges as zones of uplifting: the bending of the layers into folds was easiest attributed not to pressure on the earth's crust from below, but to its compression in a horizontal direction.

Thus arose the hypothesis of compression of the earth and crumpling of its surface. It received support in the cosmogonic concepts of the time in which it was postulated that the solid bodies of the solar system were formed during the cooling of blobs of red-hot gas. The hypothesis of the earth's compression prevailed in science over the course of the greater part of the 19th century and up to the third decade of our century.

This was a very productive period in structural geology, in the study of the morphology of structures in the earth's continental crust. In addition, it was also productive in the discovery of the principal patterns of combination of structures and the history of their development. This was the time of formulation of the principles of continental tectonics and indeed, continental geology in general.

However, with the accumulation of new data on structures of the earth's crust and the history of their development, it became increasingly clear that the



complexity of the structure and history of the earth's crust does not fit in the narrow framework of horizontal compression alone. A search for new, more complex generalizing ideas began. Since, in addition to compressional structures, structures of the graben or rift type were also encountered in the earth's crust, whose formation had to be attributed to dilatation, rather than compression, it was postulated that in the earth's history there was an alternation of epochs of compression and dilatation. This hypothesis of the earth's "pulsations" was popular in the 1930's of our century.

---

Biographical notes concerning author:

Vladimir Vladimirovich Belousov, corresponding member, USSR Academy of Sciences, section head at the Physics of the Earth Institute, USSR Academy of Sciences, chairman of the Interdepartmental Geophysical Committee, USSR Academy of Sciences, chairman of the Scientific Council on Complex Investigations of the Earth's Crust and Upper Mantle, USSR Academy of Sciences. Specialist in the field of tectonics of the earth, author of more than 200 scientific studies, including the monographs: OSNOVNYYE VOPROSY GEOTEKTONIKI (Fundamental Problems in Geotectonics), Moscow, 1962; ZEMNAYA KORA I VERKHNYYAYA MANTIYA MATERIKOV (Earth's Crust and Upper Mantle of the Continents), Moscow, 1966; ZEMNAYA KORA I VERKHNYYAYA MANTIYA OKEANOV (Earth's Crust and Upper Mantle of the Oceans), Moscow, 1968; ENDOGENNYYE REZHIMY MATERIKOV (Endogenous Regimes of Continents), Moscow, 1978. In PRIRODA he has published the article: "Program for Study of the Earth's Deep Layers in the Soviet Union" (No 1, 1982).

---

But advances in geology again overtook generalizations. They all the more demonstrated the extraordinary complexity and great diversity of combinations of structures. The earth's crust of the continents had been explored in a great many large and small regions differing with respect to type of structure and history. And hence arose a new hypothesis that the forces causing the development of structures are fitted directly to each of such regions, bypassing adjacent sectors. And this is possible only in a case when the forces are directed vertically, from the deep layers of the earth toward the surface. Then the effect of the deep forces can vary from one region to another.

An important change was noted in continental tectonics -- the most important place was occupied by vertical forces and vertical movements, whereas horizontal compression or horizontal dilatation of the crust became a secondary phenomenon, subordinate to the primary vertical movements.

Convexities and depressions are formed at the earth's surface as a result of the effect exerted on the earth's crust by forces directed from below. Slopes are created in the bedding of the layers. Gravity causes a slow sliding of rock layers along the slopes of convexities. Encountering resistance from the lower-lying layers, the sliding layers are crumpled into folds. This is also regarded as a secondary manifestation of compression in the earth's crust against the background of its primary vertical movements.

Such ideas were developed in the 1940's and 1950's. To a certain degree there was a return to the ideas of Lomonosov, but, to be sure, at a completely new level. These revised old ideas made possible a better understanding of the reciprocal relationship of different processes in the earth's crust than did the hypotheses of compression and pulsation of the earth: its movements, rising of magma melts and metamorphism of rocks. It might be said that a general theoretical base was constructed beneath the totality of endogenous geological processes, that is, those related to the internal forces of the earth.

It is probable that these ideas concerning the primacy of vertical forces and movements in the earth's crust would have prevailed in science for at least as long as the compression hypothesis had prevailed if another important circumstance had not arisen. The fact is that until then geology in general and tectonics in particular were purely continental sciences. The earth's crust under the ocean remained completely unstudied and in no way was taken into account in the generalizations. The oceans were taken into account for the first time at the beginning of our century when the very first geophysical observations indicated that the ocean floor should differ in composition from the continental crust. Whereas the latter was primarily granitic, as was then assumed, the oceanic crust was probably basaltic. This clarifying nonuniformity of the earth's crust, in combination with some other considerations (among which the parallelism of the opposite shores of the Atlantic Ocean played almost the main role) was the point of departure for appearance of the hypothesis of continental drift. Its author, A. Wegener, postulated that the continents prior to the beginning of the Mesozoic constituted a single, integrated continent Pangaea, which then broke into parts and these parts diverged, like granite floes floating on an ocean of basalt. The Atlantic and Pacific Oceans were formed between them. However, at that time there were too few factual validations for this hypothesis; the movement of the granite continents along the basaltic bed seemed to be mechanically impossible and therefore the Wegener hypothesis did not receive recognition in those years.

The situation changed in the late 1950's and in the 1960's when mankind entered the epoch of the scientific and technical revolution. In the field of the earth sciences the scientific and technical revolution was expressed in enormous progress in methods for studying the earth's deep layers, especially in geophysical methods.

The broad application of the latter made it possible to clarify many features in the structure of the earlier inaccessible lower layers of the crust of the continents and the upper mantle underlying them. It became possible to study the interrelationship between the geological structures observed at the surface and the thickness of the crust, the nature of its separation into layers of different density, as well as the properties of the upper layers of the mantle. In the mantle at a depth of 100-200 km below the surface in many regions there was found to be areas of reduced density, probably a partially melted layer, the asthenosphere, playing, it can be surmised, an important role in the formation of magmas and in tectonic movements. Thus, methodological possibilities appeared for formulating study of problems relating to the deep causes of geological processes.

At the same time the development of these same methods also became accessible for study of the earth's crust under the oceans. Here they played a completely special, decisive role. The fact is that geophysical methods are capable of collecting information on the structure of the ocean floor through the water layer. And thus the enormous oceanic expanses occupying two-thirds of the earth's surface, earlier inaccessible for study, were for the first time subjected to intensive investigation. The development of oceanic research to a more than small degree was favored by the fact that after the Second World War the ocean acquired a strategic as well as an economic importance and became the object of attention of many governments.

As a result, a great number of research ships were sent out to the seas and oceans, collecting geophysical data concerning the structure of their floor. Technical progress made it possible to supplement geophysical research with the drilling of abyssal holes. An international project was developed for drilling on the ocean floor. As a result, the boreholes drilled from a special drilling ship in all the oceans at several hundreds of points intersected the sedimentary layers at the ocean floor and raised samples of sediments to the surface. The geophysical data were also supplemented by geological information on the composition and age of the rocks lying on the bottom.

These investigations very rapidly led to discoveries of fundamental importance. The very first discovery was that the earth's crust under the oceans in actuality is not similar to the continental crust with respect to mineralogical composition or structure. These differences proved to be still more profound and fundamental than was assumed earlier.

The continental crust has an average thickness of about 40 km; under high ranges it attains 70 km and nowhere is thinner than 20 km. It is characterized by an exceedingly diverse composition and a complex structure. Both of these are imprints of a prolonged history full of complex events: tectonic deformations, injection of melted magma, change in rock structure under the influence of high pressures and temperatures. The duration of this history is almost 4 billion years (the most ancient rocks known on the continents have an age of 3.8 billion years). The cover of sedimentary rocks, very different in composition, locally attains a thickness of 20 km. The masses of magmatic rocks injected into the crust have the most different composition, from ultrabasic rocks, poor in silica and rich in magnesium and iron, to ultraacidic with a high silica content. In the continental crust a considerable role is played by various metamorphic rocks: gneisses and crystalline schists. Folded zones of different age, where the rocks have been subjected to strong deformations, occur widely on the continents.

A very special world opened up before geophysicists and geologists on the ocean floor.

The sedimentary layer on the ocean floor is very thin: distant from the continents and islands its thickness is in no case more than 200-300 meters. These ocean sediments have persisted in an unconsolidated state, they have not become denser and have not been subjected to metamorphosis. They are very young: the most ancient of them date back no farther than the Middle Jurassic

(about 170 million years). Jurassic sediments are known only in a few areas over the greater part of the oceans the most ancient sediments are Cretaceous and still younger. They become increasingly younger with approach to the mid-oceanic ridges, which in the form of very gently sloping and broad rises have extended from ocean to ocean for 60,000 km. Everywhere beneath this thin sedimentary cover are the very same extremely homogeneous basalts belonging to the so-called tholeiitic group of basalts, relatively poor in alkalis, light rare earths and radioactive elements. Judging from geophysical data, the thickness of this basalt is 1.5-2.5 km. At greater depths is a denser layer nowhere accessible by boreholes, but known from individual fragments consisting of diabbases, gabbros, amphibolites, ultrabasic rocks and serpentinites. Its thickness is about 5 km. Thus, the thickness of the entire solid (without the water layer) earth's crust beneath the ocean is only about 7 km.

The sedimentary layers on the ocean floor have an exceedingly gentle slope. Over enormous areas they are absolutely horizontal. Deformations are encountered only toward the mid-oceanic ridges and other underwater rises and plateaus scattered at considerable distances from one another. All these are block dislocations: they are associated with the uplifting of individual bottom blocks. There are no folded zones on the ocean floor similar to the continental folded zones.

Thus, geologically these two crusts are completely different. To a certain degree only those sectors of the continents which are covered by so-called plateau basalts, extensive basalt outpourings in some places covering many hundreds of thousands of square kilometers, are similar to the ocean floor. Examples of such plateau basalt covers are found on the Deccan Plateau in India (where the covering material is of Cretaceous and Paleogene age) or in the basin of the Tunguska River in Siberia (where the basalts poured out in the Late Paleozoic and the Early Mesozoic). But a continental crust nevertheless is preserved beneath the plateau basalts, although it is thinner than in other places.

It is natural that the special character of structure of the ocean floor required its explanation. Existing explanations, based on investigations of the continental crust, evidently were not suitable and it was necessary to formulate a new concept which would generalize data on the structure and development of the entire earth's crust with both its continental and oceanic sectors.

However, the movement of thought proceeded somewhat differently. The main reason for this can be seen in the relative difference in the roles which geology and geophysics have played in study of the continents and the oceans. Although geophysical methods are used extensively in study of the continents, nevertheless the decisive word in this case belongs to geology, which on the basis of its material checks geophysical constructions and imposes definite restrictions upon them. In the study of the oceanic crust the main role for the time being is played by geophysics. By virtue of the special conditions which the investigator of the ocean floor encounters geology here takes a secondary role. These methodological differences also determined the difference in the predominant professional makeup of the research personnel. On the one hand, on the continents it is geologists who are most important; over the course of two centuries it is they who developed classical continental geology. On the other



hand, it is geophysicists who during recent decades have been studying the ocean floor. It is important that geophysicists have come to the subject from backgrounds not with geological training, but primarily with physical and mathematical educations. It is scarcely surprising that new people, coming from completely new material, not burdened with the weight of the traditions of continental geology, have striven to develop their own generalizing system, completely based on what they have discovered on the ocean floor. With a concept developed, and it must be said, with surprising rapidity, they have come to consider the name of "tectonics of lithospheric plates," or "the tectonics of plates."



Map of structural elements of earth's crust according to "plate tectonics" the principal element of the crust is large plates, indicated on the map by the letters EA -- Eurasian, AF -- African, AM -- American, IA -- Indo-Australian, T -- Pacific Ocean, N -- Nazca, ANT -- Antarctic. The plates are separated from one another by the mid-oceanic ridges and subduction zones.

- Mid-oceanic ridges separated from
- Transformed faults
- Subduction zones
- Major limits on ocean floor



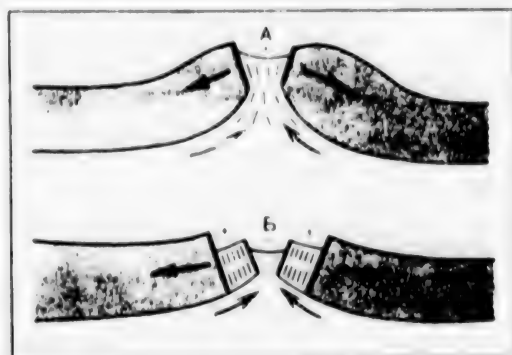


Diagram of process of spreading in mid-oceanic ridge. Stage A: melt from the mantle penetrates into the gap between the separating lithospheric plates; after cooling it is magnetized in a positive geomagnetic field. Stage B: the next batch of melt from the mantle penetrates into a new gap between the separating plates; since an inversion of the magnetic field occurred during this time this portion is magnetized negatively after cooling. Thus, alternating zones of positively and negatively magnetized rocks are formed.

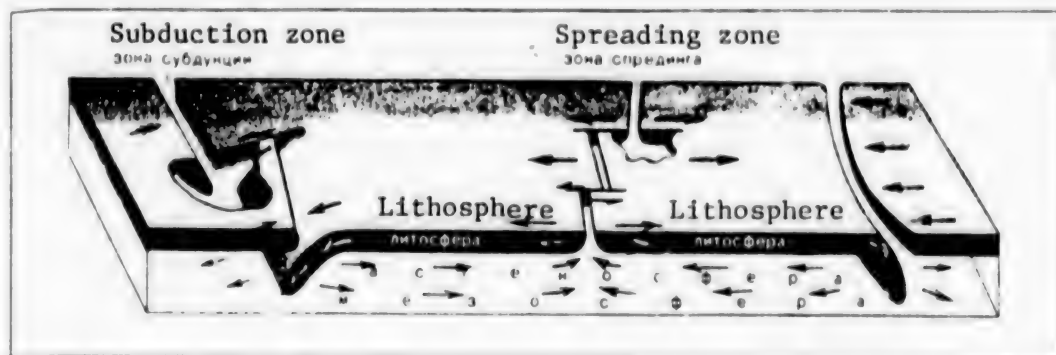


Diagram of movement of lithospheric plates. The plates are built up in the spreading zones (at the center of the figure), spread apart and descend into the asthenosphere in the subduction zones (at right and left).

The content of this concept has been repeatedly outlined in both the special and in the popular science literature, and this makes it possible here to be very brief.

As already mentioned, geophysical data make it possible to surmise that beneath the earth's solid crust and the solid part of the upper mantle, forming jointly that which is known as the lithosphere, there is a softened, partially molten layer, the asthenosphere. It has been discovered both under the continents and under the oceans, at different depths in different places (usually between 100-200 km) and with different thicknesses. The basis for "plate tectonics" is that this layer, by virtue of its low viscosity, exerts a small resistance to possible horizontal movements of the lithosphere along it. The latter is separated into several very large plates. The boundaries between them are zones where strong earthquakes occur, that is, seismic zones. The main zones

of this type are the Pacific Ocean zone, surrounding the Pacific Ocean, the most active on the earth, the Mediterranean-Himalaya zone, and also that which is associated with the mid-oceanic ridges. These seismic zones outline the American, African, Indo-Australian, Eurasian, Pacific Ocean, Nazca and Antarctic plates.

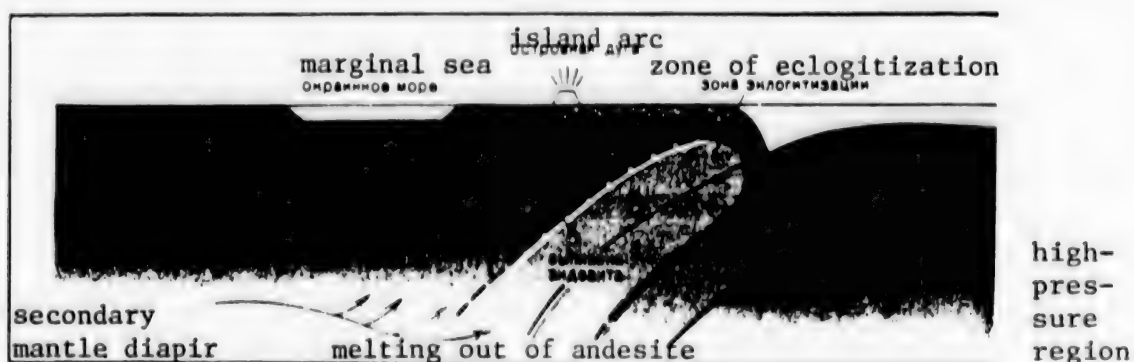
The mid-oceanic ridges, in addition to the fact that they are seismic, are also characterized by a high heat flow, recent basaltic volcanism, as well as the fact that according to seismic measurements the earthquakes here are related to dilatation of the earth's crust. As a result of the latter, ever-broadening fissures are formed along the axis of the ridge. These fissures are filled with basic and ultrabasic magma, rising from the mantle. Cooling in a fissure, the magma forms a new narrow block of the oceanic lithosphere.

Further considerations are related to the fact that an alternation of zones of positive and negative magnetic anomalies, parallel to the ridges, has been discovered along the axis and on the "wings" of the mid-oceanic ridges. It is known on the basis of measurements of so-called remanent magnetization of rocks of different age that over the course of geological history an inversion of the magnetic field has occurred, at which times the northern and southern magnetic poles have changed places. It has been proposed that zonal anomalies are a reflection of these inversions and constitute a singular magnetic geochronological scale forming in the process of separation of lithospheric plates from the axis of a mid-oceanic ridge. When the next batch of magma cools in the fissure opening up along the axis of the mid-oceanic ridge it is magnetized in the magnetic field which exists at that time. The plates spread apart, a wedge of cooling basalt is divided into two halves, between which a new fissure opens up. Mantle magma is again injected into it. And if a magnetic field inversion (reversal) occurred by then, this magma mass is magnetized in the opposite direction. And so it continues: the plates spread apart and gradually are built up in the ridge crest with new bands which are magnetized first positively, then negatively. As a result, the most ancient sectors of the oceanic lithosphere are at the greatest distance from the axis of the ridge and they are replaced by ever-younger sectors toward the axis. Accordingly, in contrast to what geologists are accustomed to on the continents, where the age of the rocks usually changes vertically (downward -- more ancient, upward -- younger), on the ocean floor the change in ages occurs in a horizontal direction. This conclusion corresponds to the above-mentioned change in the age of the bottom sediments, which become increasingly younger in the direction of the crest of the mid-oceanic ridges.





This process of expansion of the ocean floor is called spreading.

An important difference between "plate tectonics" and Wegener's old concepts concerning continental drift is that according to the new concept it is not the continents which move along the ocean floor, but lithospheric plates which move along the asthenosphere. These plates have a thickness of about 100 km and include not only the continents, but also extensive regions of the ocean floor. The blocks of the continental crust are embedded into the lithospheric plates, form their local thickening and move together with them. For example, Africa and South America are separating from one another together with the adjacent sectors of the lithosphere in the Atlantic Ocean, which all the time is

growing in the axial zone of the Mid-Atlantic Ridge. However, the initial position of the continents is assumed to be the same as in the Wegener hypothesis: a unified continent Pangaea, which began to split up and separate into modern continents at the beginning of the Mesozoic with the formation of an oceanic lithosphere between them. Only the Pacific Ocean plate is purely oceanic.



Postulated processes in subduction zone. The oceanic lithosphere, sinking into the mantle, entering into a zone of high pressures and temperatures, after some geochemical transformations, is becoming a source of those andesites and granites which are typical for the island arcs and marginal continental ridges situated over the Benioff zones.

-  Alkali-basaltic volcanism
-  Limestone-alkali volcanism
-  Currents in mantle
-  Direction of plunging of oceanic lithosphere

The growth of the oceanic lithosphere in the mid-oceanic ridges and spreading should lead to an increase in the earth's surface. But since there is no basis for the assumption of a constant expansion of the earth, there must be some opposite process which would compensate spreading. Such a process, according to "plate tectonics," is so-called subduction. It occurs along the shores of island arcs and continents where there are abyssal trenches, that is, along all the shores of South and Central America, near the island arcs of the western margin of the Pacific Ocean (from Alaska to New Zealand), near the islands of Indonesia, near the Antilles and South Antilles island arcs. Here the oceanic lithosphere, gradually cooling with increasing distance from the spreading ridge, becomes heavier and heavier, and approaching the island arc or to the edge of the continent, is bent downward and sinks in the mantle. The zones of deep seismic foci, slanting beneath the continents or island arcs, are a trace of its plunging. Such zones, known as "Benioff zones," sink to a depth of 650 km. Displacements at the earthquake foci indicate either an overthrusting of the continental wing onto the oceanic wing or an underthrusting of the oceanic lithosphere beneath the continental lithosphere. It is postulated that the

absorption of the old oceanic lithosphere in subduction zones precisely compensates the growth of the new lithosphere in the mid-oceanic ridges.

Accordingly, the oceanic lithosphere is a sort of conveyor: in the mid-oceanic ridges it rises from the mantle, and in the Benioff zones it plunges back into the mantle. This explains the absence of ancient rocks on the ocean floor: the ocean floor is renewed approximately each 200 million years. The continents also participate in these movements. But due to the small density of the continental crust in comparison with the oceanic crust, the continental masses do not participate in subduction. They diverge and collide, but always remain at the surface.

Such are the very fundamental principles of "plate tectonics."

The appearance and dissemination of this concept did not mean simply a modification of the points of view concerning some specific phenomena. With the appearance of the "plate tectonics" concept a completely new attitude toward the object of study penetrated into the earth sciences; it can be said that a new philosophy of scientific research in this field of science appeared.

First we will emphasize again that "plate tectonics" is the result of generalization and a definite interpretation of the data obtained in investigations in the oceans. In its first outlines the field of plate tectonics was not interested in the continents at all. In "plate tectonics" the continents were dead blocks which, constituting parts of the plates, moved together with them, but within which nothing significant occurred. All endogenous activity was concentrated in the oceans, to be more precise, in the mid-oceanic ridges, where a new oceanic lithosphere is formed.

Later some processes occurring in the continental crust were included within the scope of this concept, but it is postulated that their causes are concentrated in the oceanic lithosphere. For example, it is assumed that in the Benioff zones, where the oceanic lithosphere plunges into the mantle, the oceanic sediments, lying on the surface of the lithosphere, are bent, thrusting into the continental crust, are piled up on the inner slope of an abyssal trench and are crumpled into folds. This possible process made it possible to regard abyssal trenches to be modern geosynclines which are gradually transformed into folded zones. It is postulated further that the oceanic lithosphere, sinking into the mantle, entering the zone of high temperatures, partially melts and the products of this melting, after some geochemical transformations, become those andesites and granites which are typical for the island arcs and marginal continental ranges situated over the Benioff zones. It is also postulated that structures of the mid-oceanic ridges are formed beneath the continental crust, which leads to a splitting of the continent and the moving apart of its blocks, between which, by means of spreading, a new oceanic lithosphere is built up. Sediments are accumulated above it. And if the blocks then again separate, the oceanic lithosphere is absorbed in the newly forming Benioff zone and the sediments are crumpled into folds.

A substantial change in principles was also a departure from emphasis on geological history and a turning toward concepts based on the registry of the



processes which are observed now, at a particular moment. Classical geology is a branch of natural history: it studies the history of the earth's crust. This history is understood at the scales of geological time, measured in the tens, hundreds and thousands of millions of years. And the laws of development of the earth's crust, established by classical geology, are also historical. Thus, the concept "geosyncline" is historical. It corresponds to a definite type of development of endogenous processes determined by their sequence and typical "geosynclinal" forms of their manifestation. A geosyncline is a zone of particularly active tectonic, magmatic and metamorphic processes developing in a definite sequence in the course of several hundreds of millions of years. A geosyncline is opposed to a platform, for which an equally prolonged endogenous quiet is characteristic.

The geophysical methods predominating in a study of the ocean floor, in contrast to geological methods, as a rule are not adapted to a clarification of the history of the earth's crust. They are directed almost exclusively to registry of present-day structure, the present-day distribution of masses with different physical properties in it, present-day processes, such as heat flow or earthquakes. In contrast to historical geology, geophysics is predominantly a science of the "present minute," studying the present-day status of the earth's deep layers.

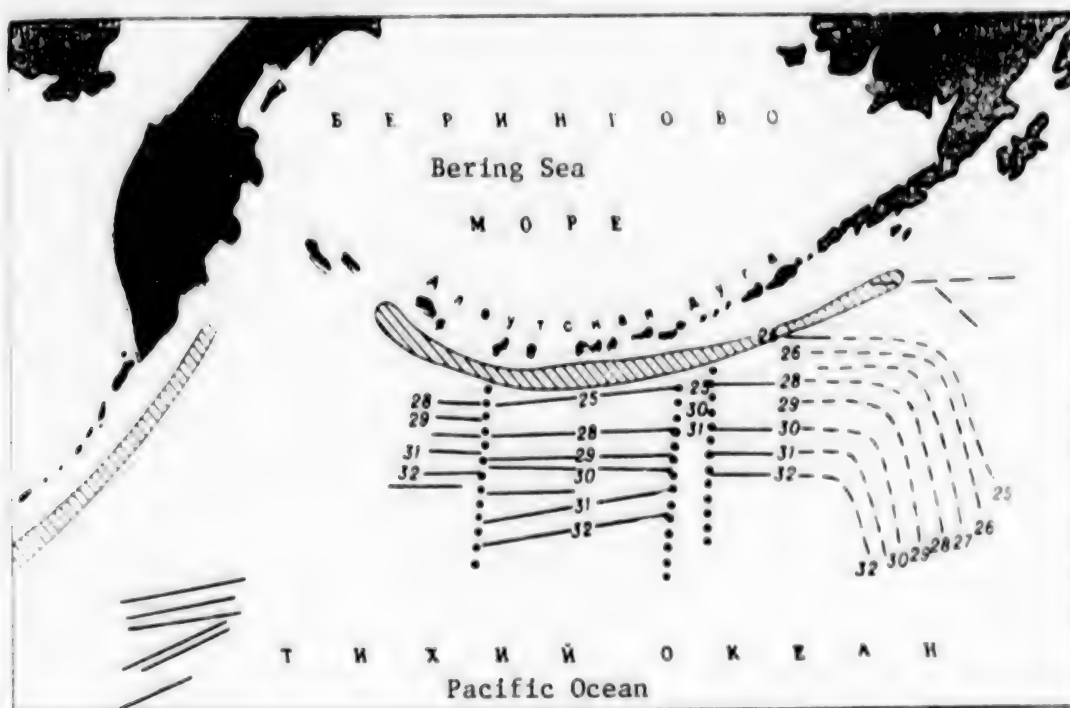
It is therefore not surprising that a singular "present-minute" approach has been introduced into the earth sciences with these new methods: the generalization formulated by "plate tectonics" is not based on the features of long-term development of the crust, but on the peculiarities of present-day processes in it. The lithospheric plates are outlined on the basis of zones of present-day seismicity. The latter, in general, is a unique indicator of present-day tectonic activity. The direction of movement of the plates is determined, in particular, on the basis of displacements at the foci of recent earthquakes. In accordance with such an approach there is a completely different formulation of the problem of the regularities in development of the earth's crust. In essence, those regularities which are dealt with in classical geology simply do not exist for "plate tectonics." It denies the reality of the "geosyncline" concept because there are no criteria for discriminating geosynclinal zones in the modern structure of the crust. In actuality, there are no such criteria in "present-minute" data because "geosyncline" is a historical rather than a "present-minute" concept and it is possible to define geosynclinal zones only by a study of the prolonged history of the earth's crust. Here there must be a time coordinate which does not exist in "plate tectonics."

The "present-minute" nature of the fundamental initial data does not favor the revelation of long-term regularities in development of the earth's crust. And this leads to a frame of mind in which all kinds of laws are denied. The history of the crust is represented in the form of a sequence of events in which there is no correctness, no relationship between the subsequent and preceding.




Assuming that lithospheric plates are in constant movement along the asthenospheric layer, "plate tectonics" limits the depth at which the causes of endogenous geological processes can occur, the bottom of the lithosphere; such a



limitation relates to processes which develop stably and over a long time at one and the same place on the surface. These causes cannot be situated deeper than the bottom of the lithosphere, for example, in the asthenosphere, since any sector of the lithosphere during its movement should rapidly be detached from this deep process.

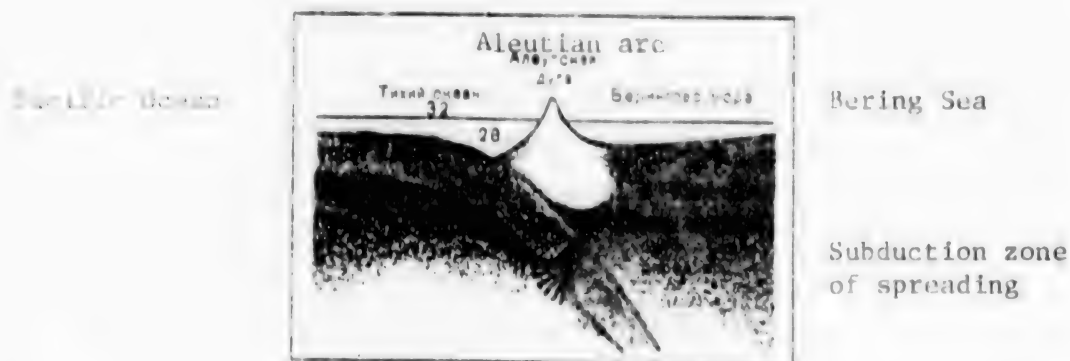


Location of zonal magnetic anomalies on Pacific Ocean floor near the Aleutian island arc. More recent anomalies are situated closer to the abyssal trench than more ancient anomalies. The sequence of numbering of anomalies in the figure is 25 (about 63 million years) to 32 (about 76 million years). Thus, the idea therefore arose that the spreading zone was earlier situated to the south of the island arc, but with the passage of time it moved northward and was absorbed by the subduction zone.

-  Mantle anomalies
-  Abyssal trench
-  Transverse ("transformed") faults

Such a limitation on the depth of penetration of the factors responsible for endogenous geological processes contradicts many of the latest data. Seismological observations, for example, indicate that appreciable differences in the elastic properties of matter between the continents and oceans are traced to a depth of at least 400 km, that is, greater than the depth of the asthenosphere. This is also indicated by gravimetric data. Geochemical investigations of recent years, especially isotopic, also lead to the conclusion that there is a considerable heterogeneity of matter situated not only in the

crust, and also situated in the upper mantle under the continents and oceans. All these manifestations of deep inhomogeneities, directly related to separation of the earth's crust into continents and oceans or zones of different tectono-magmatic activity, in no way can be consistent with horizontal movements of lithospheric plates. The latter, moving, should be cut off from the deep processes and then there would be a total noncorrespondence between surface geodynamic and deep processes.



Postulated spreading at the mid-oceanic ridge (that is, the spreading zone) under the Aleutian arc into the subduction zone. The large arrow indicates the main direction of the lithospheric plates; the small arrows indicate the movement of the plates away from the spreading zone, superposed on the main movement. The figures represent the numbers of the magnetic anomalies.

one of the paleomagnetic reconstructions of location of the continents in the end of the Paleozoic (Van der Pligton, with simplification, 1970). One should note the abnormal position of the Gyransky Peninsula, the enormous width of the ocean between Brazil, on the one hand, and India and Australia, on the other, as well as the great distance between Alaska and Chukotka. This entire configuration corresponds to different geological ages.



However, the problem of causes in "plate tectonics" has by no means been solved. Usually there is talk in general form about convective flows in the earth's mantle as the cause of movement of plates. But no one has succeeded in developing a physically sound model of such convection. Accordingly, "plate tectonics" today remains a purely kinematic concept representing the nature and direction of movements in the earth's lithosphere, but not explaining why such movements occur. This also distinguishes "plate tectonics" from earlier concepts in the earth sciences, which have always striven to expose the reasons for phenomena, at least hypothetical.

How is it possible to evaluate all these new approaches in the earth sciences?

The oceans in actuality cover two-thirds of the earth's surface and therefore it may be that it is correct to proceed to the development of a generalizing concept on the basis of data on the ocean floor. However, the continental crust, although it occupies less area on the earth's surface than the oceanic crust, is known to be far more complex than the oceanic crust with respect to both composition and structure. Many such events have left their traces in it which are known not to have occurred in the oceanic lithosphere, such as acidic magmatism, folding and the metamorphism of rocks. It is not less significant that the history of the oceanic crust, documented by rocks and organic remains, begins only 170 million years ago, whereas the history of the continental crust is traced in the depths of geological eras for almost 4 billion years. Accordingly, in posing the question of clarification of the most general and long-manifested regularities in development of the earth's crust we should not turn to the oceans, but to the continents. And only on them can we study the entire range of processes and rock formation and the formation of structures.

The question naturally arises: is it logical to attempt to comprehend complex and heterogeneous processes transpiring in the course of prolonged geological time on the basis of phenomena which are far more uniform, simple and brief? The difficulties which "plate tectonics" experiences in the interpretation of events transpiring within the continents give a legitimate answer.

For example, that which "plate tectonics" tells us about the structure and development of folded zones takes us back a hundred years to the time when the American geologist A. Dana for the first time mentioned that folds are formed by horizontal compression of the crust in deep downwarps filled with marine sediments. Since that time, geology, it is true, has made great advances in the development of the theory of geosynclines and the formation of folded zones. Instead of fold formation geologists now speak of "crowding" of the lithosphere, with this streamlined term taking in all concepts concerning different types, and accordingly, different mechanisms of fold formation, patterns of their distribution, stages in folding, dependence of fold formation on earlier crustal inhomogeneities, etc., etc.

Meanwhile, the proper and complete understanding of the history of development of the earth's crust of the continents and those regularities which are manifested in this development are of both theoretical and practical importance. All metallogenetic prediction is based on such an understanding.

The denial of regularities and also the absence in this concept of any ideas concerning the reasons for the observed and postulated processes relieve the researcher of many obligations and give rise to conditions favoring arbitrariness on his part. If there are no restrictions with respect to concepts concerning causes and with respect to general regularities in development of the earth's crust it is exceedingly easy, using some "game rules," and using additional hypotheses, to explain any geological situation. And possible alternatives are simply not discussed.

For example, although in accordance with the ideas of "plate tectonics" in general form the postulated movements of large plates are rigorously consistent with one another, the researcher, striving to explain any specific geological conditions, considers it his right to introduce any changes into this scheme of movements. He allows, for example, that large plates can be fragmented into small plates and the latter can acquire their own movements. Thus, arbitrary movements and rotations of many small plates are postulated for "explaining" the complex structure of the Mediterranean Sea, squeezed between two large plates -- African and Eurasian. It is assumed that the rate and direction of movement of the plates can vary and the spreading axes can "jump" from place to place. And all this is postulated for each case separately, without any consistency between them. Accordingly, quite often it seems that the reconstruction for a particular region is made without taking into account what is occurring in adjacent sectors. Or far more general phenomena are lost from sight as being a process of a local character.

Such an inconsistency applies even to such a classical example as the "opening up" of the Atlantic Ocean. This "opening up" should have occurred from the beginning of the Cretaceous to our time. Finally the amplitude of the spreading attained 5,000 km. Allowing this, it is somehow forgotten that for the spreading apart of the Eurasian and American plates there had to be a place to which they could move. Meanwhile, on the other side of the globe the northeastern part of Eurasia was joined into a single continent with North America: Chukotka and Alaska were separated by a shallow shelf with a continental crust, were geologically unified, and there is no possibility of postulating that earlier they were separated by an ocean with a width of several thousand kilometers which "closed" in compensation for the "opening up" of the Atlantic. If such a closing suture does not exist there, it probably must be sought somewhere within the modern continents of Eurasia or North America. In this case it is a mandatory condition that the suture had to exist in the form of an ocean prior to the Cretaceous and that it gradually closed with the onset of this period. The real geological structure of both Eurasia and North America makes it possible to assert categorically that such a suture existed in neither place. In such a case how did the "opening up" of the Atlantic Ocean occur?

Phenomena which are postulated in the region of the Aleutian island arc give rise to legitimate perplexity. Here there is an inverse sequence of magnetic anomalies: the younger anomalies are situated closer to the abyssal trench, whereas normally the reverse should be the case. Hence the idea arose that a zone of spreading of a latitudinal strike was earlier situated to the south of the island arc. But with the passage of time it moved northward and finally was absorbed by the subduction zone situated near the arc. Being now submerged



into the mantle to a depth of several hundreds of kilometers, this zone, despite such a radical change in surrounding conditions, nevertheless remains a zone of spreading and nevertheless a new lithosphere is being formed. Such an interpretation goes into the realm of mysticism.

Or, for example, it is well known that the structure of the North American Cordilleras is very complex. This folded zone is separated into extremely diverse sectors and their interrelationship in a number of cases is difficult to understand. The solution of this problem evidently requires additional detailed geological investigations. But "plate tectonics," taking advantage of the absence of restrictions, "solves" this problem extremely easily: it is assumed that a continent existed earlier in the middle of the Pacific Ocean. It was rent into pieces in different directions by deep flows and some of them reached the North American continent and "stuck" to it, thus being "alien" for all other regions of the Cordilleras.

Such reconstructions of plate movements are frequently validated on the basis of paleomagnetic data. Moreover, it can be stated that now the sole independent validation of the kinematics of plates is afforded precisely by paleomagnetism. However, the interpretation of paleomagnetic measurements adopted in our day is at least disputable.

As is well known, the paleomagnetism phenomenon involves the following. Some rocks retain evidence of the magnetization acquired in earlier geological times when there was either a cooling of the melt (if the rock was of magmatic origin) or there was primary precipitation of sediments on the floor of a water body (if the rock was sedimentary). From the orientation of this past magnetization it is possible to determine the position of a particular sector of the earth's crust relative to the magnetic pole. The orientations of paleomagnetization are different in rocks of different age and different geographic location. In principle consistency can be obtained if we are to assume that the continents or their individual sectors where paleomagnetic measurements are made moved and rotated on the earth's surface. This is the procedure of geological interpretation of paleomagnetic data.

Leaving to one side the circumstance that the results of paleomagnetic measurements have already been repeatedly reexamined with the improvement of the method, have been rejected and radically changed and that this process is continuing at the present time, it can be seen that by no means not everything in this young field has been finally confirmed; we conclude, as suggested by the leading Soviet paleomagnetologist A. N. Khramov, that the interpretation of paleomagnetic data is based on three hypotheses:

1. Rocks at the time of their formation are magnetized in the direction of the geomagnetic field of the time and place of their formation.
2. Acquired primary magnetization persists at least partially in rocks at a geological time scale.
3. The geomagnetic field, averaged for any time intervals on the order of  $10^5$  years (except inversion epochs), is the field of a dipole placed at the center



of the earth and oriented along its axis of rotation.

All of these hypotheses can cause one degree or another of doubt since in individual specific cases they are untrue. The third hypothesis, based on the now adopted concepts concerning the origin of the earth's magnetic field, which themselves are hypothetical, is particularly unreliable. It is sufficient to assume that in past geological periods there were stable magnetic anomalies of such an intensity as, for example, the present-day East Asian anomaly (or somewhat more intense) and this latter hypothesis becomes untenable and paleomagnetic data could be interpreted without invoking movements of the continents. It would also be possible to exclude horizontal movements of the continents if an off-center position of the dipole is assumed.

Such doubts are all the more reinforced by the fact that in a whole series of cases the interpretation of paleomagnetic data also definitely contradicts obvious geological data. For example, geology indicates that a direct tectonic connection between Europe and Africa through the Gibraltar and Rif zones, on the one hand, and Calabria and Sicily, on the other, existed at least from the end of the Paleozoic. But paleomagnetic reconstructions violate this linkup even for the Mesozoic and Paleogene. Paleomagnetic reconstructions in the same way violate the ancient geological connection between Chukotka and Alaska. They postulate the existence of an extremely broad ocean in the Mesozoic in the location of Central and Southeast Asia, which is fully refuted by geological data.

It follows from everything said above that in no way is it possible to consider the presently accepted interpretation of paleomagnetic data to be indisputable, much less decisive. This exceedingly interesting research method requires still further development and more thorough thinking through.

It can be seen from the preceding materials that there are many vulnerable places in "plate tectonics" and on the whole it is far from geological-geophysical reality. However, if this concept is regarded as the next hypothesis in the series of other hypotheses preceding it, then in principle the degree of its applicability to the real subterranean world is in no way different from the latter. Indeed, those hypotheses also were not able to cope with their task and did not give an entirely persuasive answer as to how the earth's depths are structured and change.

We know that a scientific hypothesis is a necessary research method. No one expects a final answer to all questions. From the hypothesis we expect guidance with respect to the most promising directions for further research. Further research not only modifies, but frequently completely refutes a particular hypothesis. The entire path of science is strewn with the corpses of former hypotheses. Each hypothesis reflects for its time the status of science, the sum of accumulated factual material, the frame of mind of researchers, the problems which precisely at the particular moment attracted their maximum attention. But it would be rash to see the end of the road in a hypothesis. This truth is possibly especially applicable to generalizations in the earth sciences, to the field where so much is still unknown with respect to the composition, properties and state of matter in the earth's deep layers, and even

the first borehole drilled in the ancient continental crust, to a depth of only 11 km, posed a mass of perplexing problems for geologists and geophysicists. Precisely the fact that approach to the truth through a series of hypotheses is an endless process is also the most attractive aspect of science. The modern philosopher K. Popper states: "The scientific game in principle has no end. Anyone who ever decides that scientific utterances are not in need of further checking and can be regarded as finally verified, is knocked out of the game"\*.

But if "plate tectonics" is regarded as the next working hypothesis, we find basis for evaluating its role in the development of the earth sciences on the whole to be positive. Not because it introduced concepts concerning plates and their mysterious movements. Its positive influence is of an indirect character. Formulating some principles of the earth sciences in a language more customary for physicists and mathematicians than geological language, it has attracted the attention of many representatives of these disciplines to the problems of structure and development of the earth. As a result for the first time it was possible to have an integrated approach to study of the deep layers, in which quantitative methods have come to play a major role. The enormous publicity which accompanied "plate tectonics" from the very beginning also played a role of more than a little importance in bringing new energies and new methods into the earth sciences.

And although the enormous intensification of interest in the earth sciences throughout the world and the corresponding increase in the volume of research in this field were determined for the most part, to be sure, by more general factors, the mentioned properties of "plate tectonics" on their part favored this same process to a considerable degree. Here we meet with a curious paradox, but one well known in the history of science, when an essentially untrue idea plays a positive role in scientific progress.

Only recently the earth sciences were left to a small body of academic scientists. But now there is a whole army of researchers who have modern apparatus and high-yield methods, as well as special ships and artificial earth satellites. Methodological and technical possibilities have appeared for posing a great number of completely new questions with respect to the properties and behavior of matter in the earth's deep layers. And the everyday work of this great army of researchers is bringing results which, independently of the theoretical concept adhered to by different scientists, now and undoubtedly in the future will retain permanent value. For the time being they have not been systematized. Their generalization to more than a small degree is being hindered by the striving to make them conform to the kinematics of "lithospheric plates." But precisely they, sort of by-products of "plate tectonics," in the long run will lead to a more perfect system of points of view which will come to replace this concept.

However, the search for alternatives has already begun. Some researchers assume that it is possible that the relationship of geological processes to great depths, where their causes are found, can be tied in with the concept of spreading of the continents, provided that it is assumed that the earth is increasing in volume and accordingly, its surface area is increasing. Thus was born the hypothesis of an "expanding earth," which already was discussed briefly in the scientific literature in the 1940's and 1950's.

\* Popper, K., LOGIKA I ROST NAUCHNOGO ZNANIYA (Logic and Growth of Scientific Knowledge), Moscow, p 78, 1983.

Other researchers prefer to return to the "pulsation hypothesis" in modified form.

There are, finally, possibilities which the author of these lines feels are most promising: an understanding of the processes of development of the earth's crust as a result of the nonuniform release of heat from the internal parts of the earth into its outer shells. Observations show that the degree of modern tectonic and volcanic activity of different zones on the earth's surface correlates directly with the magnitude of the heat flow released from the deep layers. Stronger magmatism, greater mobility of the earth's crust and the metamorphism of rocks are associated with increased heating of the upper mantle. The crumpling of layers into folds also can be attributed to the heating of the crust, when a process similar to convection develops in the latter.

If it is assumed that there is a network of deep "channels" or zones of increased permeability in the earth's crust along which deep masses carrying heat float up to the surface, this can explain the nonuniformity of manifestation of tectonomagmatic regimes at the surface. And the nonuniformity of rising of hot masses in time can explain tectonomagmatic cycles and in general the change in the activity of geological processes with time.

In the light of this concept the oceans are secondary formations and the oceanic crust formed as a result of destruction of the continental crust with an especially great heat flow, earlier covering the earth's entire surface. The temperature in the upper mantle rises to such a degree that 60-70% of its matter is melted and in the process ultrabasic magma is melted out which penetrates into the continental crust, splitting it into blocks, and is poured out atop it. And after this heavy magma solidifies, the continental crust, block by block, sinks into the upper mantle and is dissolved in it. And a new oceanic crust is formed in the place of the continental crust. Water is also released from the crust and mantle, gradually filling the downwarping depression.

It is desirable that this system of points of view be discussed in greater detail separately.

It would be natural to expect an active striving on the part of the adherents of "plate tectonics" to develop alternative concepts. Unfortunately, the atmosphere created around "plate tectonics" does not correspond to this expectation. Instead of checking their models and refuting them, laying bare their contradictions, the authors of the models prefer to seek out among the facts only certain confirmations, casting aside everything which does not correspond to this concept. However, if the contradictions are too flagrant and there is no way to get around them, additional models are formulated. A whole forest of such additional hypotheses has now risen from the surface of the main idea of "plate tectonics." It is simply not allowed that the fundamental principles of "plate tectonics" be subjected to doubt. Such circumstances, to be sure, do not favor rapid progress and the formulation of more modern points of view.

It remains to hope that this situation is temporary. In the enthusiastic state of the adherents to "plate tectonics" there is much from the enthusiasm of the

first discoverers of the geological world of the oceans. But in it there is possibly something from the traditional prejudice of some representatives of the precise sciences against the qualitative methods with which classical historical geology operates...

It can be surmised that when the first romantic period has passed and things get down to normal a more cool-headed and thoughtful view of reality will return. Then it will be possible to evaluate the significance of "plate tectonics" more objectively.

#### BIBLIOGRAPHY

TEKTONOSFERA ZEMLI (Earth's Tectonosphere), responsible editor V. V. Belousov, Moscow, Nauka, 1978.

Shoppo, V. N., ZEMLYA RASKRYVAYET SVOI TAYNY (The Earth Reveals Its Secrets), Moscow, Nedra, 1979.

NOVAYA GLOBAL'NAYA TEKTONIKA (New Global Tectonics), collection of articles headed by L. P. Zonenshayn and A. A. Kovalev, Moscow, Mir, 1974.

Belousov, V. V., OSNOVY GEOTEKTONIKI (Principles of Geotectonics), Moscow, Nedra, 1975.

COPYRIGHT: Izdatel'stvo "Nauka", Moskva "Priroda", 1984

5303

CSO: 1865/254



## THERMAL ENERGY RESOURCES OF THERMAL WATERS IN KAZAKHSTAN

Alma-Ata VESTNIK AKADEMII NAUK KAZAKHSKOY SSR in Russian No 6, Jun 84 pp 52-56

[Article by V. S. Zhevago, doctor of geological and mineralogical sciences, and Zh. S. Sydykov, corresponding member, Kazakh Academy of Sciences]

[Text] In addition to traditional types of fuel-energy raw materials (coal, petroleum and natural gas) the earth's deep heat, including ground water, the most mobile and heat-capacious energy carrier in the earth's crust, has enormous potential energy. Under the influence of the earth's heat these waters are heated to the boiling point, locally even being transformed into a superheated vaporous mixture. Such waters, called thermal and steam jet waters, are now being used extensively and efficiently for different purposes, including the production of electric power in Italy, New Zealand, United States, Japan, Mexico, El Salvador, Iceland, Bulgaria, Czechoslovakia and other countries.

Great resources of underground thermal waters and steam jets have also been discovered in many regions of our country. A geothermal station on Kamchatka ("Pauzhetskaya") has already been operating for many years on the basis of such waters and the construction of larger geothermal thermoelectric power stations is also in progress in Stavropol Kray. In these regions, as well as in Dagestan, Georgia, Checheno-Ingush ASSR and Krasnodarsk Kray, where high-temperature thermal waters are used extensively for the central heating of cities and populated places, at hothouse-greenhouse enterprises and for other purposes, independent administrations have been established for the use of thermal waters. At the present time the inhabitants of Tbilisi, Makhachkala, Kizlyar, Izberbash, Zugdidi and many other populated places, where each gigacalorie of heat is 3-5 times cheaper than from the combustion of traditional organic fuel, are successfully using the earth's deep heat for heating and hot water supply. In addition, in the southern part of the country and in some regions of Western and Eastern Siberia and the Far East thermal waters, in addition to balneological purposes, are also employed for the heating of smaller communal and hothouse systems.

It has been calculated and it has been checked on a practical basis that a single thermal borehole with a yield of 1,800-2,000 m<sup>3</sup>/day and with a temperature of 70-75°C makes it possible to heat 2-2.5 hectares, which will make it possible to obtain 450-500 tons of cheap vegetables in them out-of-season. Such a borehole makes it possible to supply heating to communal rooms in populated places with 4,000-4,500 people. After hot water supply thermal waters



can be reused, especially for filling fish ponds (for example, in Krasnodarsk Kray), which considerably increases economic efficiency.

It can be seen from what has been said above that thermal waters are a major, still inadequately exploited reserve for heat and power supply for different economic enterprises in many regions of our country. This is not only an enormous dynamic smoke-free, waste-free and fuel-free natural "boiler," whose heat makes it possible to heat cities and hothouses, to establish greenhouses and swimming pools, meet various technological needs (pumping into petroleum strata, washing of wool, etc.), but also these waters are an important potential source of electric power. According to the estimates of specialists, the predicted exploitable resources of thermal waters in our country with a temperature from 50 to 250°C are 20-22 million m<sup>3</sup>/day, which can ensure an annual saving of 140-150 million tons of conventional fuel [1]. In addition, these resources are renewable and therefore are virtually inexhaustible. Already in the current five-year plan in our country 260 million m<sup>3</sup> of thermal waters will be exploited for heating and hot water supply, which is the equivalent of 2.5 million tons of conventional fuel.

It has been established that thermal waters with a temperature greater than 40°C and a mineralization less than 10 g/liter are economically potentially suitable as sources of thermoelectric energy. As a result of many years of research [2-7] considerable resources of such waters have been detected in Kazakhstan both in regions of folded mountains and in extensive platform regions. During recent years, as a result of the deep drilling carried out in the territory of the republic, many new data have been obtained and sectors and regions of thermal anomalies [2] with the mentioned parameters found, being potential deposits of thermal waters of thermal energy importance. Such sectors and regions are characterized by increased and high geothermal gradients, an extremely stressed geothermal regime and a relatively great density of heat flows, as a result of which the heat fields of these areas are characterized by high temperatures.

These investigations have indicated that the principal resources of thermal waters are in regions of detected thermal anomalies, taking in primarily the central zones of intermont depressions and extensive platform downwarps in the thickness of Mesozoic (and partially Paleogene-Neogene) deposits. Here the geothermal gradients are not less than 3.5-5°/100 m and the density of the heat flows of conductive transport of heat, depending on the lithological composition of the rocks, is 1.2-1.6 mcal/cm<sup>2</sup>. The depths of the principal promising horizons of thermal waters vary from 1 to 4 km; the water temperature at these depths increases from 40 to 100°C or more.

In the territory of Kazakhstan there are eight thermal anomalies (deposits) which are most promising for the supply of heat and power with a mineralization of the thermal waters up to 10 g/liter and a temperature greater than 40°C; these are the Alma-Ata, Panfilovo, Keles, Kyzylkum, Eastern Aral, Northern Ustyurt, Southern Buzachi and Southern Mangyshlak anomalies. Their total natural reserves, according to data of the Hydrogeology and Hydrophysics Institute, Kazakh Academy of Sciences [2], are about 900 km<sup>3</sup> and the heat supplies in them are more than 50 billion Gcal. Their regional exploitable resources have been determined at 2.3 million m<sup>3</sup>/day with total potential heat

resources of almost 130,000 Gcal/day (see table). Such a quantity of thermal waters when used for the heat supply of urban and rural enterprises is equivalent to the heat of combustion of not less than 12 million tons of organic fuel annually.

In the Ili artesian basin there are two thermal anomalies: Panfilovo and Alma-Ata. The thickest of these, with the greatest number of strata, is the Panfilovo anomaly, situated in the eastern part of the basin between the Dzhungarian Alatau and Ketmen' Ranges. Here the most promising water-bearing horizons of thermal waters occupy primarily sandy-conglomerate strata of Neogene, Paleogene, Cretaceous and Jurassic deposits with a total thickness up to 350-450 m. They lie at a depth from 0.7-1.0 to 3.5-4.3 km where the water temperature varies from 40 to 140°C. The yields of boreholes reaching these horizons vary from 10-30 to 70 liters/sec, whereas the Cretaceous horizons give artesian flows up to 100-120 liters/sec or more. The mineralization of the thermal waters as a whole from the margin to the center of the depression and with depth varies from 0.4-1 to 10 g/liter. The least mineralized waters are those of Cretaceous deposits -- not more than 1.5-1.7 g/liter, whereas the most mineralized are the thermal waters of the lower horizons of Neogene and Jurassic deposits in the central regions of the depression.

The Alma-Ata thermal anomaly on the west adjoins the Panfilovo thermal anomaly where there are two commercially valuable water-bearing complexes in the thickness of sandy deposits of the Neogene and Paleogene with a total thickness up to 70-100 m. Their depth varies from 0.7-1 to 3.5 km and the water temperature varies from 40 to 100°C. The yields of boreholes with artesian flow or small decreases in water level vary from 10 to 35 liters/sec and the water mineralization varies from 0.5-1 to 10 g/liter.

The total secular reserves of thermal waters in the described thermal anomalies, according to the computations of M. S. Kan [2], in the indicated water-bearing horizons attain almost 250 km<sup>3</sup> and the heat reserves in these waters attain almost 13.5 billion Gcal. A total of 85 and 82% of these are in the water-bearing horizons of the Panfilovo thermal anomaly. Taking advantage of the heads of thermal waters at 200 m and with a calculated exploitation time of 30 years, their regional predicted exploitable reserves, according to data of the Hydrogeology and Hydrophysics Institute, Kazakh Academy of Sciences [1], are 0.67 million m<sup>3</sup>/day with total potential heat resources of 33 thousand Gcal/day.

The hydrogeological-economic evaluation of use of the potential thermal energy resources of thermal waters in the Ili artesian basin (with their reckoned exploitation over the course of 30 years) with the use of an electronic computer was made at the All-Union Hydrogeology and Engineering Geology Institute. This evaluation, with different variants of the computations, directed to obtaining the optimum economic and social effects from their utilization with the minimum expenditure of personnel and materials, was made for two types (pumping and artesian) of regimes for the exploitation of the water-bearing horizons. The results of the computations indicated that for the basin as a whole the potential exploitable reserves of thermal waters in the case of an artesian exploitation regime are 115,000 m<sup>3</sup>/day, whereas the heat reserves are 5,500

Gcal/day. In such a case the annual economic effectiveness of their exploitation, with all expenditures taken into account, is about 7.2 million rubles. In the case of a pumping regime for optimum exploitation the resources of thermal waters can be increased to 453,000 m<sup>3</sup>/day and the heat resources can be increased to 20,400 Gcal/day. The annual economic effectiveness of their use, according to data of the Hydrogeology and Engineering Geology Institute, attains 25.8 million rubles.

In the Syrdarya artesian basin there are three thermal anomalies: Keles, Kyzylkum and Eastern Aral. Among these the Kyzylkum anomaly is the largest not only in the basin, but also in the republic. Here are concentrated more than 70% of the natural reserves of thermal waters (or about 370 km<sup>3</sup>) and heat (about 22,000 Gcal/day) in the entire basin and more than 80% of their exploitable resources (1.25 million m<sup>3</sup>/day and 70,000 Gcal/day).

The two most sustained water-bearing complexes of thermal waters exist in this basin: Senonian-Turonian and Albian-Cenomanian. The first of these extends over an area of about 50,000 km<sup>2</sup>. The thermal waters of the complex are found in sandy horizons at a depth from 0.9-1 to 1.8 km. In these depth intervals their temperature varies from 40 to 70°C and the water mineralization is 0.4-3 g/liter. The borehole yields in the case of artesian flow or small decreases in the static water level vary from 10 to 30 liters/sec or more. In the basin the thermal waters of the Albian-Cenomanian deposits extend over an area up to 90,000 km<sup>2</sup> and lie at a depth from 0.8 to 2.5 km, within whose limits their temperature is 40-90°C. The borehole yields are 10-40 liters/sec or more.

According to computations made at the Hydrogeology and Hydrophysics Institute, Kazakh Academy of Sciences [2], the natural reserves of thermal waters in the mentioned thermal anomalies of the Syrdarya artesian basin as a whole are determined at 510 km<sup>3</sup> with a total thermal potential of 29.5 billion Gcal. The regional predicted exploitable water reserves are 1.55 million m<sup>3</sup>/day and the potential heat resources are about 86,000 Gcal/day. These values are somewhat less than the indices for water and heat resources obtained at the All-Union Hydrogeology and Engineering Geology Institute for the case of an optimum pumping regime for the exploitation of thermal waters in the basin as a whole. According to these computations, the predicted exploitable resources are estimated at 4.75 million m<sup>3</sup>/day and the thermal resources are estimated at 114,000 Gcal/day. In this case the comparative economic effectiveness will be 135.5 million rubles/year. In the case of an artesian exploitation regime these resources will be considerably less: water -- 0.17 million m<sup>3</sup>/day, heat -- 5.75 thousand Gcal/day, and the comparative economic effectiveness will be 7.1 million rubles/year.

The Northern Ustyurt thermal anomaly was discovered in the northwestern part of the Aral Sea by a few boreholes. Thermal waters with a temperature of 40-60°C and a mineralization of 2-10 g/liter were found in a sandy stratum of Albian-Cenomanian deposits with a total thickness up to 100 m. They were reached at a depth of 900-1,300 m; in an artesian regime they give up to 15-30 liters of water per second. Due to the limited amount of data on this deposit the exploitable reserves of thermal waters were determined only approximately at 100,000 m<sup>3</sup>/day with potential thermal resources of 5,000 Gcal/day. The

# Regional Natural Reserves of Thermal Waters in Kazakhstan and Their Potential Thermal Resources

Thermal anomaly and principal water-bearing complexes	Regional natural reserves		Potential exploitable reserves		Water temperature, °C
	Waters, km <sup>3</sup>	heat, 10 <sup>9</sup> Gcal	waters, km <sup>3</sup> 10 <sup>6</sup> m <sup>3</sup> /day	heat, 10 <sup>3</sup> Gcal/day	
Alma-Ata					
Neogene-Paleogene	58	2.5	0.23	11.3	40-100
Panfilovo					
Neogene-Paleogene	76	3.3	0.28	12.6	40-110
Cretaceous	77	5.0	0.10	6.3	40-120
Jurassic	36	2.7	0.04	2.9	40-140
Keles					
Upper Cretaceous	91	4.8	0.23	12.2	40-75
Lower Cretaceous	18	1.2	0.03	2.1	40-80
Kyzylkum					
Upper Cretaceous	300	17.2	1.15	62.3	40-75
Lower Cretaceous	68	4.7	0.10	7.3	40-80
Eastern Aral					
Lower Cretaceous	32	1.6	0.04	2.0	40-80
Northern Ustyurt					
Albian-Cenomanian	100	5.0	0.10	5.0	40-60
Southern Buzachi					
Albian-Cenomanian	15	0.7	0.01	0.7	40-50
Southern Mangyshlak					
Albian-Cenomanian	30	1.8	0.07	4.3	40-70
Total	900	50.5	2.3	129.0	



approximate operational yield of the water intake from five boreholes will be 6,600 m<sup>3</sup>/day.

The Southern Buzachi thermal anomaly covers the entire territory of the downwarp of the same name in the northern part of the Mangyshlak Peninsula. Here thermal waters with a temperature of 40-50°C and a mineralization of 2-10 g/liter are present for the most part in the sandy deposits of the Albian-Cenomanian with a total thickness of 30-70 m. The yields of boreholes in the case of artesian flow attain 20-30 liters/sec. The approximate predicted exploitable resources of thermal waters of the deposit are estimated at 13,000 m<sup>3</sup>/day with a heat-generating capacity of 700 Gcal/day.

The Southern Mangyshlak thermal anomaly covers the northern part of the large downwarp of the same name. Here the most promising horizons of thermal waters are sandy strata of the Cenomanian and Upper-Middle Albian with a total thickness up to 150-180 m. The thermal waters in them with a temperature of 40-70°C and a mineralization of 2-10 g/liter are situated at a depth from 0.9 to 1.8-2 km. The borehole yields in the case of artesian flow or small decreases in static water level vary from 10-15 to 50-60 liters/sec. Preliminary computations show that their predicted exploitable reserves attain almost 70,000 m<sup>3</sup>/day and the potential heat resources are 4,300 Gcal/day.

It can be seen from the cited description of the detected thermal anomalies that the deep layers of the republic have considerable thermal energy resources of thermal waters with a temperature from 40 to 140°C or more. This is evidence of the presence of excellent prospects for their use not only for the central heating of cities and agricultural enterprises, implementation of the Food Program by means of development of hothouse-greenhouse operations, building of ponds for the breeding of fish, etc., but also as a substantial additional source for the production of electric energy. In this respect the most promising are the subterranean high-thermal, superheated waters of the central Panfilovo region and in part the region of the Alma-Ata thermal anomaly. About 100,000 km<sup>3</sup> of superheated waters with a daily thermal energy potential of not less than 5,000-8,000 Gcal are to be found in their deep layers (at a depth of 2-4.5 km).

In addition to extensive thermal anomalies of platform regions and intermont depressions considerable resources of thermal waters of low thermal potentials with a temperature up to 40°C can be found in local sectors -- zones of deep faults of folded mountain regions and in individual sectors of piedmont plains -- which can be used in the development of networks of local sanatoriums, therapeutic and rest establishments. However, despite the presence of thermal energy resources which are relatively easily accessible, which are constantly renewable and which pay for themselves quite rapidly, until now they are being used extremely inadequately. Reconnaissance and reconnaissance-exploitation work for the certification and commercial exploitation of reserves of thermal waters, including in the southern regions, where there are no local fuel resources, is being carried out at an extremely slow rate. Their reserves at present have been certified only for two boreholes in Alma-Ata and Chimkent Oblasts after their operation for many years. Individual potential sources without preliminary certification of the reserves are being used for the heating of buildings and hothouses in some populated places and also for drinking



water and irrigation in Taldy-Turgan and in part in Pavlodar Oblasts.

It is clear that the slow rates of use of the considerable thermal energy resources of thermal waters in the republic simply do not correspond to the present-day, much less the long-range requirements of the national economy. The time has come to think of the organization of an interbranch state agency for the exploration and commercial exploitation of the rich resources of thermal waters, taking into account that their extensive use will yield not only a great economic effect, but will also make it possible to make use of a major reserve of ecologically pure thermal energy.

#### BIBLIOGRAPHY

1. Dvorov, I., "Heat From the Deep Layers," PRAVDA (Truth), 7 December 1983.
2. Bondarenko, N. M., Zhevago, V. S., Kan, M. S. and Sydykov, Zh. S., TERMO-ANOMALII PODZEMNYKH VOD KAZAKHSTANA (Thermal Anomalies of Ground Water in Kazakhstan), Alma-Ata, 1981, 84 pages.
3. GIDROGEOLOGIYA SSSR. T 35. ZAPADNYY KAZAKHSTAN (USSR Hydrogeology. Vol 35. Western Kazakhstan), Moscow, 1971, 522 pages.
4. GIDROGEOLOGIYA SSSR. T 36. YUZHNY KAZAKHSTAN (USSR Hydrogeology. Vol 36. Southern Kazakhstan), Moscow, 1970, 472 pages.
5. GIDROKHIMIYA I TERMAL'NYYE VODY KAZAKHSTANA (Hydrochemistry and Thermal Waters of Kazakhstan), Alma-Ata, 1969, 196 pages.
6. Zhevago, V. S., GEOTERMIYA I TERMAL'NYYE VODY KAZAKHSTANA (Geothermy and Thermal Waters of Kazakhstan), Alma-Ata, 1972, 256 pages.
7. Mavritskiy, B. F., TERMAL'NYYE VODY SKLADCHATYKH I PLATFORMENNYKH OBLASTEY SSSR (Thermal Waters of Folded and Platform Regions of the USSR), Moscow, 1971, 132 pages.

COPYRIGHT: "Vestnik Akademii nauk Kazakhskoy SSR", 1984

5303

CSO: 1865/2

TWO SUPER-DEEP BOREHOLES PROVE VALUABLE TO SCIENCE, NINE MORE ARE PLANNED

Moscow DOMESTIC SERVICE in Russian 0800 GMT 15 Jun 84

[Text] Eleven boreholes will be sunk under the program for super-deep drilling being carried out in the Soviet Union. Two of them--the Kola borehole and the Saatly borehole in Azerbaijan--are already operational. Their depth has exceeded 12 and 8 km, respectively. The implementation of the program has been discussed at a coordinating conference of scientists and specialists which has been held in Baku.

At the conference it was noted that the Kola and Saatly super-deep boreholes had become extremely valuable scientific laboratories. The data which has been obtained has made it possible to update many ideas about the depths of the earth derived from geophysical information. This makes it possible to search for mineral resources in a more purposeful manner. Sinking of two more boreholes, in the Ukraine and Kazakhstan, began this year. Preparations are in hand for the drilling of the Kuban and Tyumen boreholes, in oil and gas regions, and the Urals, Krivoy Rog and Muruntau (Uzbekistan) boreholes in ore provinces. They will be started during the current five-year plan. Altogether 150 scientific research institutes and enterprises, representing 15 of the country's industries, are taking part in the implementation of the integrated program for super-deep drilling, which will last until the year 2000.

CSO: 1865/224

SOCIALIST-BLOC CONFERENCE ON GEOPHYSICAL DATA PROCESSING FOR OIL  
PROSPECTING

Baku BAKINSKIY RABOCHIY in Russian 29 Sep 84 p 2

[Excerpt] A scientific and practical conference held on the occasion of the 10th anniversary of cooperation among member-countries of the Council for Mutual Economic Assistance (SEV) on the problem of computerized processing of geophysical information has ended in Baku. Delegations of Bulgaria, Hungary, the German Democratic Republic (GDR), Poland, the Soviet Union and Czechoslovakia took part in this conference. More than 50 papers and reports were heard in a period of four days. Nikolay Andreyevich Sevast'yanov, head of the Field and Well Geophysics Administration of the USSR Ministry of the Petroleum Industry and head of the Soviet delegation, was asked to sum up the conference's results.

"A coordinating center, 'Interneftegeofizika', was created in SEV 10 years ago," he said. "This center has guided joint work by geophysicists of various countries. Marking the anniversary of this event, which was a momentous one for us, we summarized results of this cooperation at the meetings in Baku. These results are encouraging, it must be noted. During this time, we have developed two computerized systems for the processing and interpretation of seismic-surveying data, as well as program libraries for computers which solve complex problems of prospecting oil and gas deposits by modern geophysical methods. This work has already yielded substantial results. We have been able to discover a number of deposits in the GDR, the USSR and Czechoslovakia, on territories which were formerly considered unpromising. Incidentally, the detection of the Tarsdallyar oil deposit, which was discovered recently in Azerbaydzhan, was made possible also by a new prospecting method which scientists of socialist countries have developed."

FTD/SNAP  
CSO: 1865/90

KRIVOY ROG SUPERDEEP BOREHOLE TARGETED AT 12 KM

Moscow PRAVDA in Russian 25 Sep 84 p 2

[Article by S. Chudakov, (Dnepropetrovsk Oblast)]

[Excerpt] This is one of 11 drilling projects at which comprehensive study of the structure of the Earth's interior to determine the oil, gas and ore content of the country's main regions is being conducted with the aid of deep and superdeep drilling, in line with the program of the USSR State Committee for Science and Technology on the study of the Earth's crust and upper mantle.

"As yet, this is the only superdeep borehole in our republic," noted Ya. Belevtsev, member of the Ukrainian Academy of Sciences. Initial plans call for it to reach 12 kilometers, and beyond that it could be extended to a depth of 15 kilometers if necessary."

The Krivoy Rog superdeep drilling project has been started.

FTD/SNAP

CSO: 1865/90

#### 4,000-METER BOREHOLE SUNK FOR GEOTHERMAL POWER STATION

Kiev PRAVDA UKRAINY in Russian 15 Aug 84 p 4

[Article by A. Kuz'ma, correspondent (Beregovo Rayon, Transcarpathia Oblast)]

[Excerpt] The drilling of the first parametric borehole in Transcarpathia has ended at a depth of more than 4 kilometers. A unique geothermal power station will be built in this place.

A second parametric borehole will be drilled before the construction of this station begins. The process by which the Earth's heat will be delivered to the surface is as follows, in simplified form: water from a river is let into one of the boreholes under high pressure; it comes into contact with heated strata at a tremendous depth and then returns through the second borehole in the form of a steam-and-water mixture, which operates the power station's turbines. This water will be used repeatedly, by recycling it.

In the opinion of scientists of the Ukrainian Academy of Sciences' Institute of Technical Thermophysics, heat reserves that are concentrated in the area of the Transcarpathian Geothermal Anomaly are capable of taking the place of 5 billion tons of equivalent fuel!

Extensive construction work has begun on the outskirts of the village of Nizhniye Remety. It is here that very hot rock is located closest to the Earth's surface, according to a conclusion of geophysicists. Scientists have predicted that the temperature of the rock is as high as 200 degrees at a depth of 4 kilometers.

FTD/SNAP

CSO: 1865/332



## STATE PRIZE NOMINATION FOR WORK ON RARE-EARTH AND URANIUM MAGNETICS

Moscow PRAVDA in Russian 19 Sep 84 p 2

[Article by S. Vonsovskiy, academician, chairman of the USSR Academy of Sciences' Urals Research Center and Yu. Osip'yan, academician, director of the Academy's Institute of Solid-State Physics]

[Excerpt] Magnetic materials based on rare-earth (lanthanide) and actinide elements have attracted the attention of physicists and engineers in recent years. A new scientific direction--the magnetism of rare-earth and uranium compounds--has even come into being. A decisive role in the formation and advancement of this direction was played by the research of a group of Soviet magnetologists of the Moscow and Urals universities, the Institute of Metal Physics of the USSR Academy of Sciences' Urals Research Center, and the academy's Institute of Theoretical Physics imeni Landau. Their work-cycle "Magnetism and the Electron Structure of Rare-Earth and Uranium Compounds" has been nominated for the USSR State Prize.

Giant magnetostriction is one of the interesting and important effects discovered by the authors of this research. What this means is that the dimensions of rare-earth and uranium magnetic materials are greatly altered when magnetized in an external magnetic field. Magnetostriction is hundreds of times weaker in 'iron' magnetics.

Semiconductors whose composition includes rare earth, such as europium and ytterbium, behave unusually in a magnetic field. Their electrical resistance and optical and other properties are greatly altered in these conditions.

Atomic magnetic structures in rare-earth and uranium magnetics are strikingly diverse. Their form is altered when changes occur in temperature and the magnetic field. The authors discovered critical temperature and magnetic-field values at which the type of magnetic structure changes.

The examples cited indicate the breadth of the material and the great scientific importance of the research that has been nominated for the State Prize. Six monographs by the cycle's authors are evidence of this. These monographs summarize what is known about the physics of rare-earth and uranium magnetics on the present-day level. Two certificates of discovery confirm the fundamental character of the work.

Its practical value is certainly very great. In particular, the phenomenon of giant magnetostriction is being utilized in the development of powerful sources of ultrasound for underwater acoustics and for the study of rocks in mineral prospecting. Rare-earth magnetics with record maximum magnetization have been developed with the participation of the authors. Such magnetics are being employed as cores of superconductive electromagnets, for example. So-called inversion permanent magnets in which the field changes to the opposite one as a result of changes in temperature have been developed on the basis of rare-earth magnetic alloys. The close connection between electrical and magnetic properties makes the development of instruments controlled by a magnetic field possible on the basis of rare-earth semiconductors. Rare-earth compounds--iron garnets and orthoferrites, which were studied in detail by the cycle's authors--have become the basis of a new generation of memory and information storage and processing elements for computers.

FTD/SNAP  
CSO: 1865/71

UDC: 550.34:550.386

STATISTICAL RELATIONSHIP OF STRONG EARTHQUAKES WITH PLANETARY GEOMAGNETIC  
FIELD ACTIVITY

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 8 Feb 83; after revision 1 Jun 83) pp 339-340

POGREBNIKOV, M. M., KOMAROVSKI, N. I., KOPYTENKO, Yu. A. and PUSHEL', A. P.,  
Leningrad Department, Institute of Terrestrial Magnetism, Ionosphere and  
Radio Wave Propagation, USSR Academy of Sciences

[Abstract] Earlier studies reported a significant decrease in the geomagnetic field before strong earthquakes. This work is intended to determine possible relationships between earthquakes with magnitude greater than 7 (Soviet scale) and planetary terrestrial magnetic field activity as characterized by the  $K_p$  index. A total of 100 cases of strong earthquakes on magnetically quiet days in 1965-1975 were studied.  $K_p$  indexes were studied for two days before and two days after the earthquakes. The dispersion curve shows a significant decrease one day before each event. The relationship of the planetary  $K_p$  index with seismic activity indicates that the period of preparation for an earthquake and at the moment of the shock are reflected in the terrestrial magnetic field. Figure 1; references 8: 7 Russian, 1 Western. [150-6508]

UDC: 551.24(571.642)

FAULTS ON SAKHALIN

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 24 Mar 83) pp 77-86

KHARAKHINOV, V. V., GAL'TSEV, BEZYUK, S. D. and TERESHCHENKOV, A. A.,  
Sakhalin Scientific Research and Planning Institute of Petroleum and  
Gas, Okha-na-Sakhaline

[Abstract] Results are presented from analysis of geological, geophysical and geochemical information using some existing material and some qualitatively

new materials processed by computer based on the results of deep magnetotelluric soundings and seismic operations. This information is used to determine the location and characteristics of crustal fractures on Sakhalin Island and factors which control the process of relative movement along faults. The analysis shows that all of the main features of the faults depend on depth. The region is separated into blocks which differ significantly in lithospheric type, type and intensity of folding and deformation. The lithospheric faults which separate these blocks play a decisive role in the location of basins, sedimentation, modern tectonic movements from volcanic belts and the formation of large folded and block structures. Analysis of the development of the present network of faults on Sakhalin allows prediction of differences in the structural plans of structure formation systems in the region and can assist in oil and gas as well as metal prospecting. Figure 1; references: 37 Russian.  
[167-6508]

UDC: 550.82

#### ANOMALOUS MAGNETIC FIELD IN NORTHWESTERN PACIFIC OCEAN AND PACIFIC OCEAN PLATE KINEMATICS

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 5 Apr 83) pp 22-31

GORODNITSKIY, A. M., Institute of Oceanography, USSR Academy of Sciences,  
Moscow

[Abstract] Soviet research vessels have undertaken detailed geomagnetic surveys in the area of the Shatskiy Rise and adjacent northwest trench, with measurement of the total geomagnetic field vector modulus. The results of the surveys were used in compiling a summary map of the anomalous magnetic field for the area studied. Analysis shows that within the area in question there are clear linear magnetic field anomalies with a broad band of negative field values adjacent to the Shatskiy Rise. A model consisting of normal and reverse magnetized blocks in the magnetically active ocean crust layer was calculated for one profile in order to identify linear magnetic anomalies. The data indicate new equatorial formation of the Shatskiy Rise with subsequent movement to its present 35° position. The data indicate that the latitude of its central dome at the time of formation was about -15°. Figures 11; references 12: 7 Russian, 5 Western.  
[167-6508]

## BOUNDARY VELOCITIES OF MOHOROVICIC DISCONTINUITY AND UPPER MANTLE STRUCTURE OF PACIFIC OCEAN BED

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 13 May 83) pp 32-37

KUNIN, N. Ya. and SEMENOVA, G. I., Institute of Earth Physics, USSR Academy of Sciences, Moscow

[Abstract] A study is made of published data from deep seismic soundings of the Pacific Ocean bed. The values studied were primarily obtained on 40-60 km travel-time curves with an average of 7 to 10 points on each travel-time curve and a spacing of 3 to 5 km between points. The results were used to construct a diagram of the distribution of boundary velocities along the M discontinuity and a graph of the distribution of  $V_h^m$  for various structures as well as the entire ocean bed. Lateral changes in the velocity characteristic of the M discontinuity are found to be significantly greater than changes which might be caused by velocity anisotropies and thus apparently result from variations in tectonic activity over the ocean bed as well as the composition and state of matter in the upper mantle. Lateral inhomogeneities in the upper mantle revealed by the studies are the main indications of differences in the earth down to a depth of 1 or 200 km. The trend toward slight increases in P wave velocity with depth immediately over the M discontinuity in the Pacific ocean bed is firmly established. The lateral differences in  $V_h^m$  thus must be considered indications of the depth of mantle complexes which extend to the mantle surface. Figures 3; references 30: 14 Russian, 16 Western.  
[167-6508]

## DEEP STRUCTURE OF TERRESTRIAL CRUST AND UPPER MANTLE IN SOUTHEASTERN SIBERIA AND FAR EAST ACCORDING TO GEOLOGICAL-GEOPHYSICAL DATA

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 6 May 83) pp 46-51

SHUSTOVA, L. Ye., Institute of Geology and Precambrian Geochronology, USSR Academy of Sciences, Leningrad

[Abstract] A deep cross section of the crust and upper mantle is constructed along profiles in southeastern Siberia and the Far East, including a combination of geological structures of various stages from the Precambrian eastern Siberian platform to the contemporary zone of transition from the Asian continent to the Pacific Ocean. The length of the profiles totals over 4500 km. The distribution of the normalized gravitational field gradient



maxima and minima is used to distinguish 6 large deep blocks of the crust and upper mantle, each extending for several hundred kilometers along the profile and reaching 500-600 km in depth. The sections agree with previous concepts of the geological structure of the region. The depth cross sections presented describe the current status of the major elements in the structure of the crust and upper mantle along the profile. Figures 4; references: 14 Russian.  
[167-6508]

UDC: 550.382

#### CORRELATION RADIUS OF GRAVITATIONAL AND MAGNETIC ANOMALIES AND METHODS OF ITS DETERMINATION

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 6 Apr 83) pp 285-290

SEPKEROV, S. A., Moscow Institute of Petrochemical and Gas Industry

[Abstract] Determination of the correlation radius of gravitational and magnetic anomalies has been accomplished in previous studies. This article extends two of these previous studies and presents a number of new results leading to improvement of the previously published methods in both two-dimensional and three-dimensional cases. The formulas presented allow determination of the parameter both from anomaly data and in the frequency area based on energy spectrum data. The method is the most complete method yet published for determining the correlation radius, is suitable under all conditions of two-dimensional and three-dimensional cases for both deterministic and random gravitational and magnetic anomalies. References: 6 Russian.  
[150-6508]

UDC: 550.380

#### SELECTION OF SPACING OF MODULAR AND GRADIENT MEASUREMENT SURVEYS BASED ON STATISTICAL CHARACTERISTICS OF MEASURED GEOMAGNETIC FIELD

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 15 Mar 83) pp 291-296

BOYARSKIKH, V. G., ZOLOTOV, I. G. and ROZE, Ye. N., Leningrad Department, Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences

[Abstract] An estimate of the error in optimal interpolation and selection of spacing distance are presented on the basis of a statistical approach to two-dimensional geophysical fields. The anomalous geomagnetic field is represented as a random homogeneous field. Diagrams obtained by the method of optimal interpolation can be utilized in practice to select spacing

distances and to estimate the error in construction of magnetic maps based on the results of surveys already performed. Figures 4; references 12: 11 Russian, 1 Western.  
[150-6508]

UDC: 559.383

#### ASYMPTOTE OF SOLUTION OF PITCHER PROBLEM OF REJOINING OF MAGNETIZED LINES OF FORCE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 26 Jul 82; after revision 2 Feb 83) pp 254-260

SEMENOV, V. S., KUBYSHKIN, I. V. and KHEYN, M. F., Leningrad State University

[Abstract] A new technique is developed allowing solution of the asymmetrical problem for a compressible plasma in the two-dimensional case. The method of solution allows in principle the production of an approximation based on the Mach-Alfven number for any order of the theory of disturbances. The solution technique can be applied without significant changes to three-dimensional and unsteady problems. The method is based on the use of so-called frozen coordinates. The planar problem is studied in the case of a compressible plasma, assuming that the flow is symmetrical. The equations required for the solution are derived. Figures 3; references 14: 7 Russian, 7 Western.  
[150-6508]

UDC: 550.384

#### SPECTRUM OF GEOMAGNETIC FIELD VARIATIONS IN THE RANGE OF PERIODS BETWEEN 1 AND 10 YEARS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 4 Jan 83) pp 269-273

RIVIN, Yu. P., Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences

[Abstract] An analysis is presented of the structure of the spectrum of variations in the geomagnetic field  $F(t)$  in the range between 1 and 10 years, and the structure is interpreted. The interpretation is based on materials from worldwide observations in 1955-1978, as well as European observations in 1930-1978. There are two harmonics resulting from external causes in the series of observations studied. The two maxima are at 19 and about 41 month intervals. There are no variations which can be related to processes in the liquid portion of the earth's core, meaning that the minimum period

of internal source variations at the earth's surface is about 11 years.  
Figures 2; references 19: 11 Russian, 8 Western.  
[150-6508]

UDC: 550.377

ENERGETIC PARAMETERS OF MAGNETOTELLURIC FIELD OVER CONDUCTING CYLINDER  
(E-POLARIZATION)

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 10 Mar 83) pp 274-279

SHAUB, Yu. B., Pacific Ocean Institute of Oceanography, Far Eastern  
Scientific Center, USSR Academy of Sciences

[Abstract] A study is made of the major energy parameters of the magnetotelluric field over a comparatively good conducting circular cylinder in a surrounding medium of higher resistance. Energy and impedance parameters of the field are calculated. It is found that usage of the energy characteristics of the field in addition to the impedance characteristics can generate additional, independent information concerning the magnetotelluric fields observed. Figures 3; references: 6 Russian.  
[150-6508]

UDC: 550.387

POSSIBILITY OF DIRECT ACCOUNTING FOR ANOMALIES IN VARIABLE GEOMAGNETIC  
FIELD DURING AEROMAGNETIC SURVEYS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 30 May 83) pp 280-284

BERDICHEVSKIY, M. N. and SEDOV, S. G., Moscow State University; BSSR  
Geology Administration

[Abstract] Anomalies in the variable geomagnetic field caused by geoelectric heterogeneities in the upper layers of the earth may cause significant errors in the results of aeromagnetic surveys. The possibility is discussed of creating a direct accounting system based on the use of a base magnetovariation station. This requires determination of transfer coefficients to allow the anomalies in the geomagnetic field to be considered. The model suggested is applied to consideration of geomagnetic variations in aeromagnetic surveying. Figures 2; references 7: 6 Russian, 1 Western.  
[150-6508]

GRAVITATIONAL MODELS OF SIKHOTE-ALIN FOLDED AREA

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 25 May 83) pp 52-61

BRYANSKIY, L. I., Institute of Tectonics and Geophysics, Far Eastern  
Scientific Center, USSR Academy of Sciences, Khabarovsk

[Abstract] Assuming that the distribution of density in the middle and lower portions of the crust adheres to universal rules, standard density models can be developed. One possible model assumes the vertical density gradient to be constant at any point in the crust, while in another possible model it varies in the lateral direction. This article suggests a new approach to modeling and methods for estimating the gravitational effect of complex block density gradient models. Heterophysical boundary conditions are suggested and tested by studying the gravitational model of the Sikhote-Alin folded zone based on a deep seismic sounding profile, but the model presented in this work is only a first approximation and does not include complete analysis of local inhomogeneities. It is particularly important to attempt to determine the distribution of the density gradient on the basis of detailed seismic materials. Figures 6; references: 10 Russian. [167-6508]

CONDUCTIVITY OF SEDIMENTARY MASS ON SAKHALIN ISLAND

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 14 Apr 83) pp 67-76

AL'PEROVICH, I. M., and NIKIFOROV, V. M., Sakhalin Scientific Research and Planning Institute for Petroleum and Gas, Okha-na-Sakhaline

[Abstract] The influence of the composition and structure of rocks in the sedimentary mass of Sakhalin on electric conductivity is studied. The mineralization of groundwater and temperature conditions beneath the surface indicate a regional decrease in resistivity of sand-clay formations containing various quantities of moisture with depth. The geoelectric characteristics of lithologic complexes are noted. There are two typical types of geoelectric cross sections on Sakhalin - a three-layer type and a five-layer type. Characteristics are described for several regions. In most regions there is significant differentiation with respect to resistivity, creating favorable conditions for separation of large electrical complexes. Electric boundaries usually coincide with lithologic boundaries and resistances depend directly on the lithologic composition of the rock. Mean longitudinal resistance varies smoothly in plan except for sharp variations in the upper 50 to 300 m of the cross section. Figures 3; references: 10 Russian. [167-6508]

## PROPAGATION OF NONLINEAR SEISMIC WAVES IN MEDIA WITH ELASTICITY, VISCOSITY AND PLASTICITY

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 4, Apr 84

(manuscript received 18 Jul 83) pp 839-942

KONDAUROV, V. I. and NIKITIN, L. V., Institute of Earth Physics  
imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] A material model with a nonlinearity elastic response to slight perturbations, sensitive to deformation rates in the plastic state, is used to explain certain qualitative properties in the solution of the problem of propagation of nonlinear seismic waves. The behavior of a homogeneous isotropic elastic-viscous-plastic material in the adiabatic approximation is modeled by a system of differential equations supplemented by finite relationships. The equations derived lead to the conclusion of uniqueness and continuous variation of the solution of the problem as a function of the initial data within a certain area which satisfies conditions described in equations presented in this article. References: 7 Russian.  
[156-6508]

UDC: 550.34+539.3

## KEYBOARD MODEL OF STRONG EARTHQUAKES IN ISLAND CHAINS AND ACTIVE CONTINENTAL FRINGES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 4, Apr 84

(manuscript received 18 Jul 83) pp 843-847

LOBKOVSKIY, L. I. and BARANOV, B. V., Institute of Oceanography  
imeni P. P. Shirshov, USSR Academy of Sciences, Moscow

[Abstract] The keyboard model allows the sequential stages of accumulation and release of stress in the structural element of a system to be made more concrete, relating them to definite phases in the interaction of a plate and an island chain block during one seismic cycle. The following main phases of the interaction are distinguished: complete relaxation of elastic elements; an intermediate phase in which one block passively moves with respect to the other; the phase of interaction between block and plate; the catastrophic phase; and the aftershock phase. The model is essentially kinematic and contains qualitative concepts of the interaction between the block and the plate which require theoretical and experimental verification. Figures 3; references 15: 14 Russian, 1 Western.  
[156-6508]



## ESTIMATE OF ACTIVITY OF ELBRUS VOLCANO

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 4, Apr 84  
(manuscript received 12 Aug 83) pp 952-954

KHITAROV, N. I., corresponding member, USSR Academy of Sciences,  
SHCHUKIN, Yu. K. and SIZOV, A. V., Institute of Geochemistry and Analytic  
Chemistry imeni V. I. Vernadskiy, Moscow

[Abstract] Observations in recent years have indicated that a thermal anomaly is present beneath Elbrus volcano. Five-day seismic observations recorded earthquakes including a group of events quite different from local earthquakes normally recorded in adjacent regions of the northern Caucasus. The epicenter is shallow. The position of the magmatic core is estimated to be 3 to 4 km below sea level. Elbrus is still a living volcano, possibly preparing for renewed activity. Figure 1; references: 6 Russian. [156-6508]

## GEOMAGNETIC STUDY OF AMPERE SEAMOUNT

Moscow BYULLETEN' MOSKOVSKOGO OBSHCHESTVA ISPYTATELEY PRIRODY: OTDEL  
GEOLOGICHESKIY in Russian Vol 59, No 3, May-Jun 84  
(manuscript received 11 Apr 83) pp 124-128

GORODNITSKIY, A. M. and NAZAROVA, Ye. A., Institute of Oceanography;  
Institute of the Lithosphere, Moscow

[Abstract] Ampere Seamount is located in the North Atlantic 300 km west of the Strait of Gibraltar. It rises more than 3.5 km above the surrounding sea floor. An area magnetic survey performed over Ampere Seamount showed that the anomalous magnetic field above this rise has complex anomalies in both directions with intensities of up to a few hundred nT. A positive anomaly with an amplitude of up to 1000 nT is located over the eastern peak of Ampere, a negative anomaly of up to 400 nT over the northern peak and a negative anomaly of up to 700 nT over the western peak, replaced by a positive anomaly of up to 400 nT at the 1000-m isobath. Analysis indicates that Ampere is a volcano with a thin sedimentary cover. The authors measured the magnetic characteristics of basalt collected from Ampere. The results confirm the predominance of multidomain grains in the initial magnetic materials. The grain morphology is characteristic for slowly cooling bodies. It is estimated that the peak of the seamount was probably above the ocean surface as recently as 80,000 years ago. Figures 4; references 9: 8 Russian, 1 Western. [165-6508]

INFLUENCE OF DEMAGNETIZATION OF MAGNETIC ANOMALIES OF INTRUSIVE OBJECTS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: GEOLOGIYA I RAZVEDKA  
in Russian No 3, Mar 84 pp 122-124

BLOKH, Yu. I., Moscow Institute of Geological Prospecting  
imeni Sergo Ordzhonikidze

[Abstract] A study is made of the influence of demagnetization on three-dimensional models of intrusive formations. Numerical modeling showed that demagnetization has a significant influence on the magnetic anomalies of intrusive objects, requiring proper consideration of demagnetization in solution of all problems related to qualitative interpretation of magnetic anomalies above intrusions, particularly when modeling and selection methods are used. Figures 3; references: 4 Russian.  
[164-6508]

UDC: 553.98:551.243.4'244.1(575.4)

KOPETADAG UPTHrust ZONE AS NEW OBJECT OF SEARCH AND PROSPECTING OPERATIONS  
FOR OIL AND GAS

Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO-  
TEKHNICHESKIKH, KHIMICHESKIKH I GEOLOGICHESKIKH NAUK in Russian No 1, 1984  
(manuscript received 10 Oct 83) pp 82-86

KHODZHAKULIYEV, Ya. A., PANASENKO, O. M. and PAYTYKOV, Ch. M., Turkmen  
Scientific Research and Geological Prospecting Institute

[Abstract] The area where the Kopetdag adjoins the cis-Kopetdag depression, with extensive upthrust and overthrust structures, is interesting from the standpoint of prospecting for oil and gas. Presence of specific components such as heavy hydrocarbons, benzene, toluene, etc. in ground water, as well as increased microjointing, indicate the possibility of oil finds. A system of studies is suggested to solve both scientific and applied problems, answering the question of the role and scale of cover formations, the level of horizontal and vertical stress involved in the development of the Kopetdag, the deep structure and early developmental history. Figures 2; references: 7 Russian.  
[196-6508]

STRUCTURE OF SEDIMENTARY-VOLCANOGENIC COVER OF EASTERN KAMCHATKA BASED ON  
MAGNETOTELLURIC SOUNDING DATA

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 31 Mar 83) pp 93-96

MOROZ, Yu. F., Kamchatka Geophysical Expedition, Elizovo

[Abstract] Regional electric prospecting studies were performed on eastern Kamchatka by magnetotelluric soundings to study the structure of the sedimentary-volcanogenic cover. The major tectonic elements in the area studied are linearly extended, allowing the crustal section to be represented approximately as two-dimensionally heterogeneous media. The transverse curves, more sensitive toward the upper portion of the geoelectric cross-section, were used to study the Cenozoic sedimentary mass. Longitudinal magnetotelluric sounding curves, less sensitive to the presence of intermediate screens in the section, were used to study the entire Meso-Cenozoic mass over the crystalline basement. The structures found are noted and described. Figures 2; references: 1 Russian.  
[167-6508]

SEISMICITY OF KURIL ISLAND SYSTEM IN RELATION TO ISOSTATIC CRUST STATUS

Novosibirsk TIKHOOKEANSKAYA GEOLOGIYA in Russian No 2, Mar-Apr 84  
(manuscript received 19 May 83) pp 90-93

SERGEYEV, K. F., KIM CHUN UN, ROMASHOVA, O. N., Sakhalin Complex Scientific Research Institute, Far Eastern Scientific Center, USSR Academy of Sciences, Novoaleksandrovsk

[Abstract] Studies were made to determine the quantitative variation among the major parameters of the present-day seismic process in the Kuril Island system and specifics of the isostatic state of the crust there in order to estimate the depth of penetration of fault zones on the island. This required determination of qualitative relationships between seismicity and geophysical peculiarities of a number of tectonic structures. It is concluded that the structure consists of blocks and that contemporary vertical block movements are anti-isostatic and result from warping and breakup of the lithosphere due to horizontal compressive forces. There is a system of both longitudinal and transverse structural inhomogeneities, reflected in the dynamic characteristics of the contemporary tectonic process. The fault zones are shown not only to intersect the crust through its entire thickness, but also to penetrate into the upper mantle at least to the asthenospheric layer, where lithospheric blocks are compensated. Figures 3; references: 10 Russian.  
[167-6508]

## 24-YEAR VARIATIONS IN GEOMAGNETIC FIELD AND CORRESPONDING VARIATIONS IN SEISMICITY AND VOLCANISM

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 22 Sep 83) pp 266-268

KALININ, Yu. D., and ROZANOVA, T. S., Institute of Physics  
Imeni L. V. Kirenskiy, Siberian Department, USSR Academy of Sciences

[Abstract] Mean values of X, Y and Z were taken from published sources for three observatories in the southern hemisphere for the period 1905-1974. Changes in the three elements from year to year were computed and the spectral composition of the changes was analyzed by the maximal entropy method. Quasiperiodicities at about 11, 23, 59-62 years were found for all three observatories. A general planetary westerly drift of volcanic activity was observed. It is suggested that the 24-year fluctuations in the solid subcore of the earth discussed in earlier works may be the prime cause of the 23- to 25-year geomagnetic variations noted by the three observatories. References 6: 5 Russian, 1 Western.  
[150-6508]

## MANIFESTATIONS OF BASALTOID VOLCANISM IN INTRACONTINENTAL TECTONIC STRUCTURES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 3, Mar 84  
(manuscript received 12 Jul 83) pp 688-691

GENSHAFT, Yu. S. and SALTYSKOVSKIY, A. Ya., Institute of Earth Physics  
Imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow

[Abstract] Basaltoid volcanism on the continents has occurred widely in various geotectonic structures in various stages of development of the crust. One clear example of Cenozoic epiplatform tectonic-magmatic activation is the Baykal-Mongolian region. The results of seismologic and gravimetric studies have shown that activation of the Baykal-Mongolian region during the Cenozoic resulted from the anomalously thin mantle. Magnetometric studies have shown that magma hearths occur at various depths. Seismologic data indicate the presence of a subcrustal anomalously hot mantle layer beneath all neovolcanic areas in the Caucasus, another example of a highly mobile structure in the Cenozoic stage. These two areas of different tectonic structural development reveal regularities in the manifestation of mantle basaltic magmatism. In both regions the main source of tectonic-magmatic activity is the thin, hot upper mantle, the development of which is associated with the development of basaltic magma. References: 15 Russian.  
[181-6508]

UDC: 552.3:550.382.3(479.25)

INFLUENCE OF CYCLICAL LOAD AND LONG-TERM PRESSURE ON MAGNETIC PARAMETERS OF  
BASALT IN GARNI GEODYNAMIC TESTING AREA, ARMENIAN SSR

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: NAUKI O ZEMLE in Russian  
Vol 37, No 1, Jan-Feb 84 (manuscript received 5 Jul 83) pp 45-51

AVCHYAN, G. M. and NAGAPTEYA, V. V., Yerevan State University; Institute of  
Geophysics and Engineering Seismology, Armenian Academy of Sciences

[Abstract] A study is made of the results of investigation of the influence of cyclical static loads on magnetic characteristics of rock. Studies were performed on basalts from the Garni geodynamic testing area in Armenia. Cyclical loading and long-term application of pressure were studied to determine their influence on saturation magnetism, induced anisotropy and coercive spectra of the basalt. Long-term pressurization suggests redistribution of the internal stress structure and resultant changes in the magnetic structure-sensitive parameters. The results indicate that for specimens containing magnetite when held under pressure, potential barriers resulting from the high internal stresses from such sources as crystal lattice defects are significant in the retention of displacement of domain boundaries. No significant changes in magnetization were observed with time when specimens were held without loading, but under cyclical loading with a periodicity of one hour and a total length of eight hours, natural remanent magnetization decreased by 13 to 18%. Long-term loading decreases saturation magnetization and reduces the amplitude of the coercive spectra. Figures 7; references: 8 Russian.

[190-6508]



# LONG-TERM MEAN SEISMICITY CHARACTERISTICS OF ARMENIAN SSR AND ADJACENT REGIONS (BASED ON 1962-1980 DATA)

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: NAUKI O ZEMLE in Russian  
Vol 37, No 1, Jan-Feb 84 (manuscript received 23 Nov 81) pp 61-68

NAZARETYAN, S. N., ASLANYAN, S. R. and KIRAKOSYAN, A. A., Order of Labor  
Red Banner Institute of Geophysics and Engineering Seismology, Armenian SSR

[Abstract] This study was based on earthquakes with energy class K at least 9 recorded between 1962 and 1980 in Armenia. The distribution of epicenters over the area is mapped, and those in the 1970's tended to be more strictly located along a meridional line than those in the 1960's. This is probably an artifice resulting from the greater accuracy of epicenter coordinate measurement in the later period. Deformation maps are presented based on the cube root of the square of energy of each earthquake. Characteristics of seismic activity and repetition tendency are described. The maximum possible earthquake for the Armenian SSR and adjacent regions is calculated to have energy class  $K_{\max} = 16$ . In the central portion of the republic  $K_{\max} = 15$ . Potential inaccuracies of the method are briefly discussed, in that it is based on studies of the history of past earthquakes, while new, strong earthquakes do not always occur in areas where past earthquakes have been observed. Figures 4; references 7: 6 Russian, 1 Western.  
[190-6508]

# JOINT USE OF LONG-TERM SEISMIC PRECURSORS FOR CAUCASUS

Yerevan IZVESTIYA AKADEMII NAUK ARMYANSKOY SSR: NAUKI O ZEMLE in Russian  
Vol 37, No 1, Jan-Feb 84 (manuscript received 3 Oct 83) pp 69-73

APTSIAURI, P. V. and CHAKHMAKHCHYAN, A. G., Institute of Geophysics,  
Georgian SSR; Institute of Geophysics and Engineering Seismology, Armenian  
Academy of Sciences

[Abstract] This article studies the possibility of determining and using three long-term seismic precursors in the Caucasus for 1962-1980. The use of the roy-S, Sigma-L and activation-deactivation-AD precursors for possible prediction of strong earthquakes requires regionalization of a territory. The Caucasus was divided into five regions and these long-term seismic precursors were studied for each region. Two parameters were used to determine and apply the precursors: the minimum magnitude of strong earthquakes and the alarm time. The algorithm for detection and application of the precursors is described. Adjustment of regional boundaries was used to improve the stability of the results. Of 8 strong earthquakes, 7 could be retrospectively predicted by the use of the three precursors, with an average alarm time of 20%. There was one false alarm. Figures 6; references: 4 Russian.  
[190-6508]

SPECIFICS OF EARTH'S THERMAL CONDITIONS BENEATH FOCAL AREA OF TASHKENT EARTHQUAKE

Tashkent UZBEKSKIY GEOLOGICHESKIY ZHURNAL in Russian No 2, Mar-Apr 84  
(manuscript received 7 May 83) pp 14-16

ZUYEV, Yu. N. and ULOMOV, V. I., Institute of Geology and Geophysics  
Imeni Kh. M. Abdullayev, Uzbek Academy of Sciences; Seismology Institute,  
Uzbek Academy of Sciences

[Abstract] Regular geothermal observations were made in a special seismologic borehole drilled in late 1968 into the upper portion of the focal area of the Tashkent earthquake of 26 April 1966. This 2.5 km borehole was used for periodic temperature measurements with an accuracy to 0.01-0.05°C and for determination of vertical temperature gradient, thermophysical parameters of rock, as well as the content of radioactive elements. Similar studies were made in other boreholes in the Tashkent area. The epicenter borehole intersected all structural and formation levels represented by terrigenous rocks of the Mesozoic and Cenozoic and penetrated 135 m into the upper Carboniferous volcanites of the folded basement. The data obtained indicate that over the focus of elastic-viscous deformations joints are formed and dilatation occurs in the area. Geothermic data confirm the author's previously published article on elastic-viscous fracture which assumes the development of plastic disruption of the continuity of the medium at the focus, dilatency and crack formation in the rock above the focus.

References: 6 Russian.

[166-6508]

RELATIONSHIP BETWEEN VARIATIONS IN  $\rho_{eff}$  AND ELECTROMAGNETIC FILTRATION FIELD IN TAMDY REGION

Tashkent UZBEKSKIY GEOLOGICHESKIY ZHURNAL in Russian No 2, Mar-Apr 84  
(manuscript received 9 Mar 83) pp 17-20

MAHKAMDZHANOV, I. M. and SULTANBEKOV, R. I., Seismology Institute, Uzbek Academy of Sciences

[Abstract] Studies of the variations in effective resistivity of rock by dipole probing revealed significant variations in resistivity in areas of intensive jointing, probably related to the hydrogeological conditions of the area around Tamdy in the central Kyzylkum. The method used is based on study of the intensity of the constant electric field as a function of changes in dimensions of the apparatus. The details of the research method are not presented but the correlation between variations in effective resistivity and

the electromagnetic filtration field are discussed. Combined studies utilizing electrometric and magnetometric methods are planned for the future. Figures 2; references: 5 Russian.  
[166-6508]

UDC: [551.243+555.263.37]:550.831.017/(575.16)

INTERNAL STRUCTURE OF AREAS OF INTENSIVE DEVELOPMENT OF VOLCANOGENIC ROCK IN NORTHWESTERN PORTION OF BUKANTAU MOUNTAINS (WESTERN UZBEKISTAN)

Tashkent UZBEKSKIY GEOLOGICHESKIY ZHURNAL in Russian No 2, Mar-Apr 84  
(manuscript received 18 Oct 83) pp 20-25

KHEYFETS, V. M. and FUZAYLOV, I. A., Tashkent Order of Peoples Friendship Polytechnical Institute imeni Abu Raykhana Beruni; Experimental-Methodological Expedition, Uzbek Ministry of Geology

[Abstract] Previous large-scale geological-geophysical studies demonstrated the need for further studies of the volcanogenic rock of western Uzbekistan. The stratigraphy of the region is described. Distribution of anomalous geophysical fields in the area is found to correspond fully with the physical properties, thickness, dimensions, geometry and position of geological bodies in space. The distribution of volcanogenic rock in the Tubabergen suite is described. Quantitative interpretation is used to determine the total vertical thickness of Tubabergen suite volcanites. The subvolcanic bodies are shaft-shaped structures of complex morphology with distinct roots. The data obtained indicate the nature of the internal structure of the pre-Mesozoic formations as a trough developed by pairs of deep fractures and complicated with many flake-like upthrusts. New and promising areas of ore formation are related to individual regions of western Uzbekistan in which ore-containing masses of effusive and sedimentary rock served as the source of ore material. Figures 2; references: 7 Russian.  
[166-6508]

MANIFESTATIONS OF GAMMA FIELD IN CERTAIN AREAS OF SEISMICALLY ACTIVE MIDDLE TIEN SHAN FRACTURES

Tashkent UZBEKSKIY GEOLOGICHESKIY ZHURNAL in Russian No 2, Mar-Apr 84  
(manuscript received 13 Jun 83) pp 26-28

YAKUBOV, D. Kh., YARMUKHAMEDOV, A. R. and SATTAROV, A. S., Seismology  
Institute, Uzbek Academy of Sciences

[Abstract] A study is made to determine weakened zones, tectonic dislocations and their "viability", as well as the nature of manifestations of the gamma field before perceptible earthquakes. Radiometric profiles have been run in the basins of the Chirchik and Akhangaran rivers in the Fergana valley since 1975. The results of analysis of gamma surveys of eastern Uzbekistan and adjacent territories indicate that rocks of different composition and genetic types have different gamma activity intensities. When buried fractures and cracks pass beneath Quaternary deposits the fracture zone is not always clearly seen in gamma activity surveys. A study is made of several examples of the manifestation of gamma activity in fracture zones. It is concluded that in fracture zones, areas of modern crack formation and weakened zones, increased gamma field values are observed. The gamma field is observed to increase before earthquake aftershocks. The results of radiometric studies agree primarily with geological and geomorphological, morphometric and geodetic data. Figures 2; references: 12 Russian.  
[166-6508]

UDC: 550.341

RESULTS OF SOVIET-FRENCH STUDIES ON IDENTIFICATION OF HIGH SEISMICITY ZONES IN WESTERN ALPS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 6, Apr 84  
(manuscript received 21 Sep 83) pp 1353-1358

GVISHIANI, A. D., SALLANTEN, Kh., SAL'DANO, A., SISTERNAS, A. and SOLOV'YEV, A. A., Institute of Earth Physics imeni O. Yu. Shmidt, USSR Academy of Sciences, Moscow; Paris Institute of Earth Physics

[Abstract] The purpose of this work was to determine locations where earthquakes with magnitude at least 5.0 may occur in the Western Alps. The problem was solved independently by teams from both institutes. The studies were based on data from earthquakes with magnitude 5.0 or greater and epicenter depth not over 100 km between 1900 and 1980. The results of determinations by the algorithms used by both the Soviet and French teams are diagrammed. Territories rated as seismically dangerous by both algorithms should probably be considered the most dangerous. Figures 3; references 9: 5 Russian, 4 Western.  
[186-6508]



## STUDY OF KUMDAG EARTHQUAKE OF 14 MARCH 1983

Ashkhabad IZVESTIYA AKADEMII NAUK TURKMENSKOY SSR: SERIYA FIZIKO-TEKHNIЧЕСКИХ, ХИМИЧЕСКИХ I GEOLOGICHESKIKH NAUK in Russian No 1, 1984 (manuscript received 17 Nov 83) pp 71-76

GARAGOZOV, Dzh., GOLINSKIY, G. L., KURBANOV, M. K. and MURADOV, Ch., Seismology Institute, Turkmen Academy of Sciences

[Abstract] A study of the earthquake of 14 March 1983 in the village of Kumdag near Nebit-Dag was made by field researchers of the authors' institute and Institute of Earth Physics, USSR Academy of Sciences. The earthquake resulted in the formation of two parallel fractures about 23 km long on earth's surface. The study of these fractures indicated that the fault is a straight shear-thrust fault with a slope of about 5-10° to the vertical. The Soviet magnitude 8 earthquake was followed by several dozens of aftershocks, some of which reached Soviet magnitude 5 or 6. An isoseist map was constructed by examining damage to buildings and other manifestations of seismic intensity. For the first time in the USSR, the surface fractures passed through buildings and structures of various types, allowing clear determination of the type of damage caused by such fractures. Figures 4; references: 8 Russian. [196-6508]

UDC 546.791.027:553.434(574.31)

## FEATURES OF DISTRIBUTION OF RADIOELEMENTS IN DZHEZKAZGAN DEPOSIT

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA GEOLOGICHESKAYA in Russian No 3, May-Jun 84 pp 37-42

TROFIKOVA, L. A., SATPAYEVA, M. K. and SYROMYATNIKOV, N. G., Geological Sciences Institute imeni K. I. Satpayev, Kazakh Academy of Sciences, Alma Ata

[Abstract] A study was made of the distribution of uranium in the main varieties of rocks, ores and minerals in the Dzhezkazgan deposit in Kazakhstan. In addition to an analysis of the spatial distribution of uranium in ore-forming sulfides, its concentration was evaluated directly in microscopic sections and the absolute contents of uranium and thorium in pulverized samples of ores and minerals were determined. The study included 168 samples from Dzhezkazgan, including all mineral types of mineralized sandstones, ore veins and also ore-free sandstones and siltstones (the results are presented in 2 tables). It was found that ore-free reddish sandstones and siltstones are characterized by the highest content of uranium and its most uniform distribution. Grayish sandstones enclosing mineralization are somewhat impoverished in uranium with a less uniform distribution. Mineralized sandstones are characterized by a very nonuniform distribution of uranium, whose content decreases considerably in comparison with ore-free reddish sandstones. Continuous massive ore veins are completely



devoid of uranium admixtures. Well-formed crystals of ore minerals, growing on the walls of fractures, contain a uniformly scattered uranium admixture. The uniform enrichment of reddish sandstones and siltstones with uranium is associated with the presence of uranium in well-mixed terrigenous material and evidently with the sorption of uranium by iron hydroxides in the sedimentation process. It is concluded that the uranium in Dzhezkazgan ores is an element carried by ore-bearing fluids from the surrounding sandstones. The peculiarities of its distribution detected by radiography indicate complex physicochemical processes in which ores were formed. Figures 1; tables 2; references: 7 Russian. [195-5303]

UDC 550.837.211:551.241

#### GEOELECTRIC SECTION OF EARTH'S CRUST AND UPPER MANTLE ALONG CHARDARA-BAYZHANSAY PROFILE

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA GEOLOGICHESKAYA  
in Russian No 3, May-Jun 84 pp 52-56

AL'MUKHANBETOV, D. A., AZHIBAYEV, S. Zh., GALKIN, A. S., KAZHKINA, A. O.  
and TULEGENOV, S. I., Geological Sciences Institute imeni K. I. Satpayev,  
Kazakh Academy of Sciences, Alma-Ata

[Abstract] The geoelectric section of the earth's crust and upper mantle is described along the Chardara-Bayzhansay regional profile. Along the entire profile there is a Mesozoic-Cenozoic complex which includes deposits from Upper Triassic to Quaternary. The total thickness of the Mesozoic-Cenozoic deposits along the entire profile varies from a few tens of meters near the mountain framework to 1.5-2.5 km in depressions. The authors analyzed the geoelectric section and section of impedances along the profile in order to ascertain the structural-tectonic elements of the studied region (a full-page diagram represents these sections along the profile). The diagram shows that Mesozoic-Cenozoic deposits with different longitudinal conductivity lie on a pre-Mesozoic basement whose top serves as the reference geoelectric horizon. The formations underlying this stratum are characterized by a non-uniformity of resistivity both horizontally and vertically (with depth the resistivities decrease monotonically). The asthenospheric layer is associated with rocks close in composition to ultrabasic. It was possible to determine the positions of the structural units of both regional and local character. The downwarps of the bottom of the earth's crust correspond to rises of the M discontinuity and the asthenospheric layer. This confirms the isostatic regularity in the distribution of masses in the earth's crust and upper mantle. Figure 1; references: 11 Russian. [195-5303]

# GEOLOGICAL EFFECTIVENESS OF AUTOMATED PROCESSING OF HIGHLY PRECISE AEROMAGNETIC SURVEYS IN CASPIAN REGION

Alma-Ata IZVESTIYA AKADEMII NAUK KAZAKHSKOY SSR: SERIYA GEOLOGICHESKAYA  
in Russian No 3, May-Jun 84 pp 65-77

BORONAYEV, V. A., KOVAL', L. A., SERKOV, V. I., KALININ, M. I. and  
KOMAROVA, R. G., Geological-Geophysical Expedition, Kazgeofizika Geological  
Production Association; Kazakh Polytechnic Institute imeni V. I. Lenin,  
Alma-Ata

[Abstract] The ASOM-AGS/Yes system developed by the Kazakh Affiliate of the Geophysical Prospecting Scientific Research Institute and the Kazakh Polytechnic Institute is intended for the processing and interpretation of data from aerogeophysical surveys on Yes computers. Using this system there can be separate or combined processing of magnetic, gamma-spectral and electrical prospecting data with a topographic tie-in by different methods. A block diagram in this article shows a generalized scheme for processing in the ASOM-AGS/Yes system. The work described in the article is a highly precise aeromagnetic survey at 1:50,000 in the area of the Caspian depression and on the Mangyshlak Peninsula with an accuracy to 1 gamma. Specific details are given concerning this survey work, both the procedures used and the results obtained. The automated processing of these aerogeophysical data involves four successive stages: 1) initial processing; 2) various operations ensuring thorough qualitative and semiquantitative analysis; 3) quantitative interpretation; 4) formation of an archives of aerogeophysical and geological data on magnetic tapes, interaction of the system with the computer archives, geological generalization and interpretation of the accumulated information. The computer processing described in the article yielded a marked increase in the efficiency of magnetic prospecting work for petroleum and gas and broadened the possibilities for its use. At the same time, a number of shortcomings became evident and will now be resolved. Figures 10; references: 8 Russian.  
[195-5303]

UDC 550.837.6

# MAGNETOTELLURIC SOUNDING CURVES FOR FIVE-LAYER MODEL WITH SURFACE ELLIPTICAL INCLUSION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 3, 1984  
(manuscript received 21 Oct 82) pp 77-80

MIKHLIN, L. P., Moscow State University

[Abstract] The distorting effect of geoelectric inhomogeneities is highly important in the theory of magnetotelluric sounding. This phenomenon can be

investigated by solving a system of differential equations in partial derivatives with variable coefficients and a complex geometry of the boundaries. Such problems are solved for the most part by numerical methods. Asymptotic methods based on the low-frequency approximation are also used. The asymptotic approach makes it possible to consider the models to be static and to use solution of problems for a d-c current and also to use approximate boundary conditions for E, H correct for thin layers. In this article the latter approach is used in investigating a five-layer model whose first layer contains an inclusion elliptical in configuration. The magnetotelluric sounding curves are shown and they are analyzed. The model is structured as follows. There are five layers. The upper layer with the thickness  $h_1$  and the constant resistivity  $\rho_1 = \rho_1^e$  contains an inclusion in the form of an elliptical cylinder with the constant resistivity  $\rho^i$  and the semiaxes  $a$  and  $b$ , oriented along the  $x$  and  $y$  axes. The second layer has an infinite resistivity. The model is excited by a homogeneous wave incident from above. All the MTS curves virtually coincide in shape with the right branch of the  $\rho_N$  curve computed for a horizontally homogeneous but vertically displaced medium. A shape of the MTS curves distorted by galvanic effects is well expressed. Figures 3; references 5: 4 Russian, 1 Western. [145-5303]

UDC 550.311

# STRESSES AND STRAINS IN LITHOSPHERE CAUSED BY EARTH'S THERMOCONVECTIVE OSCILLATIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 3, Mar 84 (manuscript received 31 May 82) pp 3-20

BIRGER, B. I. and KOVTUNENKO, S. M., Institute of Physics of Earth named O. Yu. Schmidt, USSR Academy of Sciences

[Abstract] The phenomenon of the earth's thermoconvective instability is described and analyzed by the modeling of a system which is two-layered in its rheological properties. In this model the upper elastic layer (lithosphere) lies on the homogeneous mantle, whose rheology conforms to Andrade's creep law. The lithosphere-mantle boundary is defined as an isotherm. Since the temperature changes in the system this is a moving boundary. The regime of threshold convective instability which is observed in the earth with the adopted evaluations of its physical parameters corresponds to perturbations in the form of nonattenuating thermoconvective waves. The fields of stresses, strains and temperatures in the lithosphere and mantle are determined, as well as the displacements of the earth's surface and the lithosphere-mantle discontinuity arising during the propagation of a thermoconvective wave. The penetration of convective movements into the lower mantle, where the absence of a superadiabatic temperature gradient is postulated, is also examined. Finally, the influence of denudation and sedimentation processes transpiring at the earth's surface on convective movements is estimated. The results of the modeling indicated that

thermoconvective waves create stresses in the lithosphere attaining 3 kbar even with displacements of the earth's surface not exceeding 1 km. No stresses exceeding 1 kbar are observed in the earth's crust. Any further analysis of thermoconvective movements therefore require use of a rheological model which takes into account the appearance of plastic deformations and destruction in the most stressed regions. Figures 3; references 15:

6 Russian, 9 Western.

[145-5303]

UDC 550.348

#### FRACTURING OF MEDIUM AND ITS RELATIONSHIP TO SEISMIC REGIME

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 3, Mar 84  
(manuscript received 31 Dec 82) pp 21-25

TSIBUL'CHIK, I. D., Institute of Geology and Geophysics, Siberian Department,  
USSR Academy of Sciences

[Abstract] The author here examines the seismic process on the basis of concepts concerning the destruction of a continuous medium under prolonged loading as a process of accumulation of defects and subsequent macrodestruction as a result of avalanchelike unstable fracturing. In the study of the fracturing field the investigated region was broken down into areas of 25 km<sup>2</sup>, whose dimensions make it possible to neglect the influence of errors in determining the coordinates of the epicenters (5-10 km) on epicenter density. The seismic process developing during weak earthquakes is investigated using a fracturing function dependent on the density of earthquakes occurring in a unit volume from some initial moment in time. The motion of the fracturing front and the relationship between strong earthquakes and their aftershocks and places where the gradient of the fracturing function becomes equal to zero are described. It was found that the directions in which the movement of the fracturing front was a maximum velocity correspond to the directions of the main geological dislocations in the investigated seismically active zone. The course of the seismic process with time was studied and monolithic sectors whose destruction should be accompanied by an increased release of seismic energy were discriminated. The proposed method for study of geodynamic processes may well prove to be useful in solving problems involved in the prediction of strong earthquakes. Figures 4; references: 3 Russian.

[145-5303]



## SINGULARITIES METHOD APPLICABLE TO INTERPRETATION OF SEISMIC DATA

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 3, Mar 84  
(manuscript received 12 May 82) pp 35-40

VOSKOBOYNIKOV, G. M. and SHESTAKOV, A. F., Geophysics Institute, Ural  
Scientific Center, USSR Academy of Sciences

[Abstract] In an earlier article (IZV. AN SSSR: FIZIKA ZEMLI, No 3, pp 62-75, 1982) the authors presented the theoretical principles of a method for determining singularities, that is, effective sources, of geophysical fields satisfying the three-dimensional Laplace and Helmholtz equations. The results obtained there make it possible to develop a singularities method for the interpretation of three-dimensional potential and wave electromagnetic fields much as has been done applicable to two-dimensional potential fields. In the variant examined earlier the method is applied to the interpretation of a seismic field, provided that some method is used in discriminating the harmonic component corresponding to a purely longitudinal or purely transverse wave. This greatly restricts the possibilities of application of the method because the discrimination of the longitudinal or transverse harmonic field component is difficult and not always feasible. In this article it is shown that such a limitation can be avoided by developing a method for determining singularities directly for the Lamé vector equation, which corresponds to the total elastic oscillations of a homogeneous medium. The solution presented here constitutes the first stage in developing a singularities method for interpreting geophysical fields conforming to differential equations of an elliptical type. This makes possible algorithms based on a uniform methodological approach, close in structure, for interpretation of a wide range of fields: gravity, stationary electric and magnetic, wave electromagnetic and seismic. However, the method has only a quite narrow field of application (for example, it is ineffective in interpreting fields created by structures with smooth boundaries because the singularities of such fields are usually situated far from the boundaries of the investigated structures). But the method can be quite effective in interpreting fields caused by such structures as thrusts, faults and local objects such as ore bodies. This has been demonstrated on a practical basis in the interpretation of magnetic anomalies associated with iron ore deposits. Figure 1; references: 4 Russian.  
[145-5303]



# NONUNIFORMITY OF GRAVITY FIELD IN ROOMS AND CHOICE OF SITE FOR CONDUCTING GRAVITY EXPERIMENTS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 3, Mar 84  
(manuscript received 18 May 83) pp 41-49

SAGITOV, M. U., Moscow State University imeni M. V. Lomonosov; State  
Astronomical Institute imeni P. K. Shternberg

[Abstract] The author discusses the nonuniformity of the gravity field in a room in which a gravity experiment is carried out. This nonuniformity is caused by the pillars and posts, room walls, body of the instrument, etc. It is best to use the second and third derivatives of gravity potential in characterizing such nonuniformity. These derivatives are used in introducing corrections into the results of experiments. It has been found that anomalies of the second and third derivatives in rooms are substantially greater than those which are customary in gravimetric prospecting. It is shown that in order for the gravity field anomaly to be as small as possible under such circumstances it is necessary to be as distant as possible from the room walls, particularly its corners (1-2 m). It is best that the pedestals be sunk in the ground in such a way that the field anomaly will be created by masses with a difference in the density of pedestal material and the ground. It is best that the pillars be broad with placement of the instrument in the middle in such a way that the instrument sensing element is removed from it tens of centimeters to a meter vertically. Some of these recommendations contradict other requirements on pedestals with respect to massiveness and stability. There must be a compromise in each specific case, depending on the type of gravity experiment. Figures 8; table 1; references: 1 Russian.  
[145-5303]

# GEOHERMAL FIELD OF FAULT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 276, No 5, Jun 84  
(manuscript received 10 Aug 83) pp 1091-1094

SARDAROV, S. S. (Jr.) and SAVINA, Ye. V., Geothermal Problems Institute,  
Dagastan Affiliate, USSR Academy of Sciences, Makhachkala

[Abstract] A study was made of the dissipative structures which can arise in a fluid-saturated fault and manifested in the spatial ordering of the geothermal field. The authors investigated a porous medium with a rigid skeleton saturated with an incompressible viscous fluid situated in a geothermal field and in a gravity field. It was assumed that the fluid flow conforms to the Darcy law and density is linearly dependent on temperature. Such a system is examined in the Boussinesq approximation and with allowance for stationarity

of the process; the porous medium occupies a volume constituting an infinitely extended rectangular parallelepiped. The formulated problem is solved for small perturbations of temperature, pressure and velocity of the initial fixed state. Fault geometry is taken into account. It is shown that in the geothermal field of hydrogeologically active faults one should not encounter monotonically high values of the geothermal parameters, as has been assumed in the past, but instead extended anomalies of a variable sign. The findings are illustrated in two examples, faults in the region of the southern slope of the Karpinsk rise and in the Caspian syncline. These examples confirm that in the geothermal field faults are not manifested by positive anomalies, but by a string of anomalies of variable sign, provided that they are hydrogeologically active. In addition to a new geothermal fact, this confirms the possibility of convective self-organization in faults. Figures 2; references 9: 3 Russian, 6 Western.  
[239-5303]

UDC 550.384.33

# USE OF PERMINVAR EFFECT IN THERMALLY MAGNETIZED ROCKS IN DETERMINING PALEOINTENSITY

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 3, Mar 84 (manuscript received 12 Jul 82) pp 63-69

VECHFINSKIY, V. S., VINOGRADOV, Yu. K. and MOSTRYUKOV, A. O., Institute of Physics of Earth imeni O. Yu. Shmidt, USSR Academy of Sciences

[Abstract] In studies of thermally magnetized rocks it was found for some of them that the linearity of the dependence of ideal partial magnetization  $I_{rp1}$  on the permanent field  $H$  is disrupted with  $H$  close in value to the field in which thermomagnetization  $I_{rt}$  was created. On the basis of this effect a method was proposed for determining the paleointensity of the geomagnetic field--the SMR (stepped magnetic reversal) method. It has been postulated that this effect is related to the diffusion processes transpiring in thermally magnetized rock during its cooling from the Curie point in the magnetic field and the induced magnetic anisotropy arising as a result of this in the ferromagnetic substance of rock. A new method is proposed for determining the suitability of rocks for heatless methods for finding the modulus of paleointensity of the geomagnetic field. A comparative investigation of two unheated methods is made. The block diagram of the apparatus is described; with respect to its operating principles it differs in no way from apparatus proposed earlier for measuring dynamic hysteresis loops. The new method nonetheless provides an innovative approach for measuring hysteresis loops when working by the SMR method and the derivatives method for rocks containing titanomagnetites. The comparison of two heatless methods for determining the thermomagnetization field revealed that with almost identical accuracy they make it possible to determine the thermomagnetization field. The derivatives method has some advantages in comparison with the SMR method. A new phenomenon was discovered in rocks: induction of magnetic anisotropy by a variable magnetic field. Figures 8; references 7: 5 Russian, 2 Western.  
[145-5303]

## STUDYING ORIENTATION OF ORDERED SYSTEM OF FRACTURES BY SEISMIC POLARIZATION METHOD

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ZEMLI in Russian No 3, Mar 84  
(manuscript received 31 Mar 83) pp 70-76

YAKUBOV, V. A., Gidroproyekt (Hydroproject Planning and Survey Scientific Research Institute), USSR Ministry of Power and Electrification

[Abstract] The prime factor characterizing elastic, deformational and strength properties of bedrock is the orientation of fractures. Fracture orientation can also serve as an indicator of the stages of deformation and destruction of rocks transpiring before earthquakes. Since the study of diagnostic criteria for the purpose of detecting the predominant orientation of fracturing in zones of tectonic dislocations is an important seismic problem, the author here describes a class of seismic models of the real medium which can be used in investigating this problem. Emphasis is on a class of seismic models of a real medium whose studied inhomogeneity is small in scale against the background of a macroscopic inhomogeneity. Three models of a fracturing zone situated in an isotropic medium are examined in a two-dimensional region in an area measuring 90 x 190 m filled with an inhomogeneous elastic medium. In the first model each elementary volume belonging to the fracturing zone contains ellipsoidal fractures with a random orientation. In the second model in any elementary volume the fracturing zone contains an ordered system of ellipsoidal fractures whose maximum expansion axes are oriented parallel to, whereas the shortest axes are perpendicular to the top of the intact rocks. In the third model of the fracturing zone the orientation of the system of fractures was selected in such a way that the longest expansion axes of the fractures were oriented perpendicular to and the shortest axes were oriented parallel to the top of the intact rocks. These linearly elastic models made it possible to study the kinematic properties of the seismic waves propagating through the fracturing zone. It was found that the form of the travel-time curves of the transmitted waves carries no information on orientation of the fractures in the fracturing zone. It is then shown that information on orientation of the fractures can be obtained from the polarization properties of the packet of transverse waves; on this basis a diagnostic criterion is obtained for detecting the orientation of fractures. The described seismic and mathematical model of a real medium can therefore be used extensively in studying a small-scale inhomogeneity of a real medium by seismic methods. Figures 5; references 18: 17 Russian, 1 Western.  
[145-5303]

## TITANOMAGNETITES OF MAGMATIC ROCKS IN KOMANDORSKIYE ISLANDS AS INDICATORS OF GEODYNAMIC REGIME

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA GEOLOGICHESKAYA in Russian  
No 4, Apr 84 (manuscript received 5 May 82) pp 90-99

GENSHAFT, Yu. S., PECHERSKIY, D. M., BORSUK, A. M. and TSVETKOV, A. A.,  
Institute of Physics of Earth, USSR Academy of Sciences; Institute of  
Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry

[Abstract] A study was made of ore minerals (primarily titanomagnetites) in the rocks of three magmatic formations in the Komandorskiye Islands and thermomagnetic characteristics of samples of rocks with subsequent application of the results in evaluating deep conditions for development of the magmatic process and the structure of the region itself (the petrographic and petrochemical characteristics of the studied samples were described in earlier articles). The selected rock samples were investigated using a special vibrational thermomagnetometer and their Curie points were determined. In most cases there were two successive "heating-cooling" cycles, making it possible to judge the nature of change in the ferromagnetic minerals during heating in the air. All standard parameters were determined and are tabulated. It was found that most of the samples contain grains of titanomagnetites inhomogeneous in their composition. Some of these samples contain several generations of titanomagnetites which differ in their mean chemical composition. The size of the grains forming the impregnations and entering into the matrix varies from 300 to 5  $\mu\text{m}$  or less. The composition of the titanomagnetite or the degree and structure of the inhomogeneity are not dependent on grain size. Most samples contain ferromagnetic phases with high Curie points close to magnetite. The analysis reveals an explicit difference in the conditions for crystallization of titanomagnetites in rocks of the three discriminated magmatic formations, made particularly clear from a comparison of their Curie points and petrochemical coefficient. The highest  $\text{TiO}_2$  contents (and accordingly the minimum  $T_c$  values) are characteristic of titanomagnetites of rocks from the first formation. Rocks of the second formation are most representative, having a nearly normal single-mode  $T_c$  distribution. The main conclusion which can be drawn reliably from this study of titanomagnetites and the general petrochemistry of magmatic rocks is that it is possible to establish a transition from a near-platform deep regime to an island arc regime over the course of a prolonged period of development of the magmatic process. In general, the combination of changes in  $T_c$  and the petrochemical coefficient for volcanites of the second and third formations in the Komandorskiye Islands is atypical for the "classical" development of island arc volcanism. Another peculiarity of the subalkaline olivine basalts in the region is that although on the  $\text{SiO}_2 - (\text{Na}_2\text{O} + \text{K}_2\text{O})$  diagram these rocks fall completely in the field of subalkaline olivine basalts of the oceanic islands and continents, they differ from the latter in having exceptionally high Curie points and they do not exhibit such indicators of mantle depth as xenoliths and high-pressure megacrystals. Figures 2; tables 3; references 29: 14 Russian, 15 Western.

[149-5303]



## GEOHYDRODYNAMICS OF PROMISING PETROLEUM- AND GAS-BEARING COMPLEXES IN TUNGUSKA BASIN

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 2, Feb 84  
(manuscript received 14 Feb 83) pp 16-22

BUKATY, M. B., Tomsk Polytechnic Institute

[Abstract] The so-called "reduced stratum pressures" method was used in studying the geohydrodynamics of deep horizons in the Tunguska basin. The distribution of stratum energy of subterranean fluids in the complexes of the Tunguska artesian basin most promising with respect to petroleum and gas (subsalt, salt, Ordovician) is illustrated in Fig. 1. The criteria used in defining the regions most likely for the production of hydrocarbons are defined: a) there is a marked difference in the stratum pressures in the deep horizons from normal hydrostatic pressure, indicative of reliable hydrodynamic isolation of the complexes from the surface; b) there is a substantial difference in pressures in the subsalt and intersalt horizons, up to the formation of hydrodynamic inversions in the section, evidence of an absence of a hydraulic interrelationship between them; 3) there are considerable lateral pressure gradients over a great part of the basin, suggesting a structural or lithological breakup of the deep horizons into relatively isolated blocks characterized by different conditions for the formation and conservation of pressures; 4) in places there are major zones of piezominima in the subsalt and salt horizons. Each of these criteria is discussed. It is shown that in general the distribution of stratum pressures in these complexes differs sharply. The formation of the geohydrodynamic field within the Tunguska artesian basin transpires under a wide range of factors whose manifestation in different sectors of the territory may be different in intensity and direction, depending on the specific hydrogeological situation. In the southern part of the region, where the permeable zones of different horizons are usually separated and the pools are of a low capacity it is more likely to find relatively small oil and gas deposits. Northward, in regions with a calcareous type of cross section, the more distant (both lateral and vertical) migration of hydrocarbons is possible. In such regions it is possible to expect a relatively higher degree of concentration of petroleum and gas in comparison with the southern part of the basin. But the pools should be encountered considerably less frequently. Figures 2; table 1; references: 13 Russian.  
[108-5303]



## TECTONICS AND PRESENCE OF PETROLEUM AND GAS IN NORTHERN CRIMEAN DOWNWARP

Moscow GEOLOGIYA NEFTI I GAZA in Russian No 2, Feb 84  
(manuscript received 20 Apr 82) pp 41-45

BONDARENKO, V. G., All-Union Marine Petroleum and Gas Industry Scientific  
Research Institute

[Abstract] All hydrocarbon deposits in lowland Crimea and on the northwestern Black Sea shelf are located within the limits of the Karkinitsko-Northern Crimea downwarp. The gas deposits for the most part are concentrated in Lower Paleocene deposits and in the Maikop series. A paleotectonic analysis made using seismic prospecting data from the northwestern shelf of the Black Sea revealed that one of the reasons for the nonuniform distribution of hydrocarbons may be the different history of the formation of structures. This article gives an analysis of evolution of the relatively well-studied (by drilling) Northern Crimean downwarp, which since the Upper Cretaceous has been a part of the extensive Karkinitsko-Northern Crimean downwarp. This structure already existed in the preplatform stage in development of the region in the Triassic, Jurassic and possibly the Paleozoic. Thick volcanic-sedimentary strata were deposited here in subgeosynclinal facies. But information is lacking on brachystructures which are of greatest interest in the search for hydrocarbons. The history of this structure is therefore examined here only in its platform stage of development (from the Lower Cretaceous to Neogene inclusive). Figure 1 is a set of eight maps of the structural-tectonic structure of the Northern Crimean downwarp in different stages of its evolution in the Mesozoic-Cenozoic. The material presented here shows that the tectonics of the Northern Crimean downwarp is quite complex. It experienced considerable transformations in the course of its evolution. Forming in the Late Aptian-Early Albian as a narrow grabenlike downwarp in the northwestern part of the peninsula, in the Paleogene it was transformed into an extensive depression occupying the northern part of the shelf and the adjacent land. In the first stage of its formation the downwarp broke down into two branches. The eastern branch for the most part is localized on the land and has an isometric configuration. The western branch occupies the Tarkhankutskiy Peninsula, where the greatest thicknesses of sediments are situated, and it extends into the adjacent part of the shelf. The downwarp is complicated by second-order uplifts. During the course of the Cretaceous and Cenozoic these structures changed in configuration, migrated in area and at times experienced inversion. The structure of the Northern Crimean downwarp persisted virtually without changes in the Late Albian and Senonian, Early and Late Santonian. An analysis of thicknesses made it possible to detect sectors of baylike wedging-out of deposits promising in the search for traps of the nonanticlinal type. Among these those of the greatest interest for petroleum and gas exploration are formations of the Lower Cretaceous and Paleogene where collector rocks alternate with cap rocks. Figures 2; references: 2 Russian. [108-5303]

CHEMICAL KINETICS AND EARTH'S ATMOSPHERE

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 3, Mar 84 pp 95-105

TAL'ROZE, V. L., corresponding member, USSR Academy of Sciences

[Abstract] This is a review of current knowledge concerning elementary chemical processes transpiring in the atmosphere, which emphasis on work carried out at the Institute of Chemical Physics, USSR Academy of Sciences, but also the Chemical Kinetics and Combustion Institute, Siberian Department, USSR Academy of Sciences. This field is particularly important because without a knowledge of the detailed mechanism and rate of such elementary chemical transformations it is impossible to make sound forecasts of the long- and short-range influence of different substances of natural or anthropogenic origin on the atmosphere or to formulate global models of its evolution. A table accompanying the review summarizes the stages in development of chemical-kinetic concepts concerning these processes in the three principal layers of the atmosphere. With respect to chemical physics the ionosphere, stratosphere and troposphere differ in the nature of the operative chemical agents. In the ionosphere reactions with the participation of charged particles are most important. In the stratosphere reactions of products of photodissociation processes (free radicals and atoms in ground and excited states) are predominant. In the troposphere the reactions involve unstable molecules with some (but considerably less than in the upper layers) quantity of free radicals and ions. Each of the three layers is examined separately. For example, in the section on chemistry of the ionosphere particular attention is given to the formation of local zones with a reduced concentration of charged particles. The section on stratospheric chemistry is devoted in large part to the processes of formation and destruction of ozone, evaluations of the rate of these processes and such matters as the role of bromine, the OH radical and galactic cosmic rays in the behavior of the ozonosphere. With regards to tropospheric chemistry, emphasis is on the oxidation of hydrocarbons, a process leading to ozone formation and the development of photochemical smogs. Experimental methods and research apparatus currently in use are also discussed (included are mass spectral methods, electron paramagnetic resonance, laser magnetic resonance, laser resonance, intraresonator laser spectroscopy and others).  
[113-5303]

PROCESSES OF SMOOTH INCREASE AND DROPOFF IN INTENSITY OF GLOW LINE  $\lambda' = 5577 \text{ \AA}$   
WITH EXPOSURE OF IONOSPHERE TO ELECTRON BEAM

Tbilisi SOOBSHCHENIYA AKADEMII NAUK GRUZINSKOY SSR in Russian Vol 111, No 1,  
Jul 83 (manuscript received 19 Feb 82) pp 61-64

ADEYSHVILI, T. G. and MANAGADZE, G. G., Kutaisi Polytechnic Institute  
imeni N. I. Muskhelishvili; Space Research Institute, USSR Academy of Sciences

[Abstract] The "Stereotop" experiment with artificial modification of the earth's ionosphere with an electron beam was carried out on 1 December 1978 in the middle latitudes under quiet geomagnetic conditions. An electron accelerator carried aboard the rocket ensured the injection of a beam in a pulsed regime with a duration of 0.6 sec and with a period between pulses of 6 sec. With an angle of beam divergence of  $\sim 7^\circ$  the power and intensity of the current for the injected electrons were  $\sim 3 \text{ keV}$  and  $\sim 0.2 \text{ A}$  respectively. A "Fotozavr" modulation-type photometer was used in the registry of artificial ionospheric glow in the line  $\lambda = 577 \text{ \AA}$ . Other instruments carried on the rocket were for making corpuscular and wave measurements and for measuring the strength of the electric field and potential of the object. It was found that with the injection of electrons the glow intensity of the line  $\lambda = 5577 \text{ \AA}$  increases smoothly and attains a maximum 0.7 sec after onset of injection. After cessation of injection there is a dropoff in the intensity of the observed signal. It is concluded that the smooth increase in glow intensity was caused by accumulation of the energy of the excited states  $\text{N}_2(\text{A}^3\Sigma^+)$  and  $\text{O}('S)$  in the course of their existence, whereas the decrease in glow intensity after cessation of injection was caused by the quenching of  $\text{O}('S)$  by atomic and molecular oxygen. Figures 2; references 6:  
4 Russian, 2 Western.  
[225-5303]

INVESTIGATING PHASE STRUCTURE OF ELECTROMAGNETIC FIELD IN LOCAL INHOMOGENEITIES  
BY MODELING METHOD

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: FIZIKA, KHIMIYA in Russian  
Issue 1, No 4, Feb 84 pp 95-99

BUKIN, A. N., ISAYEV, A. E. and DENISON, B. G., Leningrad University

[Abstract] It is important to comprehend the influence of local inhomogeneities on the propagation of electromagnetic waves in waveguides in the case of multimodal waveguides in the UHF range and in the propagation of ULF waves in the earth-ionosphere natural waveguide. Such a study can be made by using physical spatial-temporal modeling of the processes of propagation of waves in the ULF range. In this article it is shown that a two-plane waveguide

for studying the phase structure of an electromagnetic wave in the presence of local inhomogeneities of height and conductivity. The term "local" here means "extended along the trajectory not more than several wavelengths." Two types of inhomogeneities were considered: situated on the earth (on the same surface where the source is situated) and on an opposite surface, simulating the sharp boundary of the ionosphere. Operation of the experimental apparatus is described; the transmitting and receiving antennas were in a fixed position and the inhomogeneous sector moved smoothly along one of the coordinate lines (the distance between the dipoles must exceed the interval in which the field scattered by an obstacle in the direction of the source decreases to a negligible value since only in this case is a direct measurement of the additional phase possible). The study confirmed the spatially restricted nature of the phase perturbations caused by the considered types of inhomogeneities and the distributions of the additional phase made it possible to detect the presence of some criteria indicative of the geometrical parameters of the inhomogeneities. The method ensures a phase resolution of not less than  $\pm 0.2^\circ$  with the continuous registry of the additional phase as a function of a prestipulated coordinate. Figures 7; references 10: 8 Russian, 2 Western.  
[122-5303]

UDC: 550.383

# OBSERVATION OF NATURAL NOISE NEAR UPPER HYBRID RESONANCE IN TERRESTRIAL MAGNETOSPHERE BY PROGNOZ-5 SATELLITE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 26 Apr 83) pp 249-253

ARTEM'YEVA, G. M., GRIGOR'YEVA, V. P., IVANOV, V. N., PISAREVA, V. V.,  
TARASOV, A. F., FEKLICHEVA, I. F. and SHAVSHINA, V. I., Gor'kiy  
Radio Physics Institute

[Abstract] Results are presented and analyzed from a study of natural magnetospheric noise near the upper hybrid resonance made using the Prognoz-5 satellite, launched 25 Nov 76 with an orbital period of 95 hours, perigee 500 km, apogee 200,000 km, orbital inclination  $65^\circ$ . Natural noise was studied by an apparatus designed to measure long-wave cosmic radial radiation in the 50-1000 KHz band using both a rod and a frame antenna. The results indicate that the dimensions of the plasmasphere are significantly less than those obtained in earlier works, its shape more nearly circular. Electron concentration is also lower than earlier reported. These changes apparently are related to the solar activity cycle. The high-frequency natural noise of the plasmasphere in the polar diagram of invariant latitude relative to local geomagnetic time reveals a maximum intensity in the morning and evening sectors between invariant latitudes 40 and  $62^\circ$ , which may result from the asymmetric distribution of mild particle fluxes in the nighttime plasma layer. Figures 3; references 11: 5 Russian, 6 Western.  
[150-6508]



## DISTRIBUTION OF ELECTRIC FIELD NEAR WESTWARD PROPAGATING BEND IN AURORA

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 25 Apr 83) pp 232-236

PETROV, V. G., KOZELOVA, T. V., LAZUTIN, L. L. and TREYYU, Zh.-P., Polar Geophysics Institute, Kola Branch, USSR Academy of Sciences

[Abstract] The explosive phase of a magnetic substorm produces an active area which expands in all directions. In its western portion, characteristic strong magnetic field disturbances occur. The active area is surrounded on the west by a bend in the aurora which moves along an arc toward the west. Recent studies have shown that the differential equivalent ionospheric currents near the bend in the aurora are a vortex which rotates counter-clockwise, indicating that the active area is the location of longitudinal currents flowing from the ionosphere, the western portion of a three-dimensional current system characteristic for the explosive phase of substorms. This article analyzes the results of electric field measurements from balloons launched in 1979 into the active area near and within the auroral bend. The behavior of the electrojet during passage of the auroral bend was observed. Consideration of characteristic features of the variations in the magnetic field and natural boundaries of the area of intensive precipitation in association with the auroral bend and their repetition rates at various longitudes as the bend moves westward allows a first approximation of a transition from a time representation to a space representation and analysis of data from measurement of the electric field in the system of a nonmoving bend. The major properties of the distribution of the electric field are noted. Figures 2; references 10: 3 Russian, 7 Western.  
[150-6508]

## LONGITUDINAL CURRENT BEFORE WESTWARD PROPAGATING AURORAL BEND

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 4 Apr 83) pp 228-231

KOZELOVA, T. V. and LYATSKIY, V. B., Polar Geophysics Institute, Kola Affiliate, USSR Academy of Sciences

[Abstract] It has been shown that at the western and eastern boundaries of an auroral protuberance there are two oppositely directed longitudinal currents. Further studies by the author have shown that the western area of the aurora has yet another longitudinal current extending into the ionosphere, explaining the increase observed in the eastern electric field in advance of the auroral area propagating toward the west. The distance of a current extending into the ionosphere to the west of the auroral zone has been previously observed. This work presents a study of this additional



longitudinal current to the west of the visible auroral area. The current, a clockwise-rotating vortex of equivalent ionospheric currents, encompasses the area of positive divergence of horizontal magnetic and electric field vectors. Two independent methods were used to determine the magnitude of the currents, both of which yielded approximately the same results. The current density entering the ionosphere is about  $0.5 \text{ A/km}^2$ , total current  $10^4$ - $10^5 \text{ A}$ . Figures 2; references 7: 2 Russian, 5 Western.  
[150-6508]

UDC: 550.388.2

#### IONOSPHERIC EFFECTS OF SURFACE INDUSTRIAL SHOTS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 28 Feb 83) pp 211-216

VARSHAVSKIY, I. I. and KALIKHMAN, A. D., Siberian Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Siberian Department, USSR Academy of Sciences

[Abstract] Results are presented from calculation of the parameters of the shock wave arising in the ionosphere from a shot at the earth's surface. The problem is solved by means of a numerical model of the signal reflected from the excited ionosphere. It is assumed that in the altitude region in question the wave propagates at a certain angle to the vertical at a group velocity which depends on the vertical temperature and wind speed profile. An exponential model of the ionosphere is used to calculate the parameters of the shock wave arriving at the point of observation from the shot point and to analyze the response of the ionosphere to its passage. Interpretation of observations of the ionosphere during an actual shot by radio sounding is based on the model, which describes the parameters of the radio signal passing through the ionosphere as a function of the parameters of the ionosphere itself. Figures 4; references 8: 4 Russian, 4 Western.  
[150-6508]

RELATIONSHIP BETWEEN DOPPLER FREQUENCY SHIFT SPECTRA AND PERTURBATIONS  
MOVING IN IONOSPHERE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 25 Apr 83) pp 201-204

VINOGRADOVA, M. B. and GUSEV, V. D., Moscow State University

[Abstract] A relationship is sought between the spectrum of fluctuations in the Doppler frequency shift at the lower boundary of the ionosphere (at the "screen") and on the earth. To simplify the calculations, a one-dimensional phase screen and vertical distribution are assumed. Nonlinear changes in wave phase are found to lead to nonlinear changes in the Doppler frequency shift variation spectrum and arrival angles. The degree of nonlinear changes depends on the maximum value of the focusing factor  $\kappa$ . With sloping propagation for the same values of shifting ionospheric perturbations,  $\kappa$  is greater than for vertical propagation. Therefore, additional maxima in spectra related to nonlinear changes should be more strongly expressed for nonvertical propagation. References: 5 Russian.  
[150-6508]

STATISTICAL INTERRELATIONSHIP OF MAXIMUM FREQUENCY AND SCREENING FREQUENCY  
OF MIDDLE LATITUDE  $E_s$  LAYER

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 7 May 83) pp 314-315

OKHREMCHIK, S. A. and RADCHENKO, T. A., Voronezh State University

[Abstract] There is a statistical relationship between the maximum frequency and screening frequency in the middle latitudes in the  $E_s$  layer. These frequencies follow a log-normal distribution. An equation is derived to describe the interrelationship and this was tested on the basis of hourly observations of  $f_0$  and  $f_b$  made at Kiev between May and August of 1977 through 1980. Different equations are derived for daytime and nighttime observations. Figures 2; references: 6 Russian.  
[150-6508]

## STATIONARY IONOSPHERIC DISTURBANCES BASED ON INTERCOSMOS-19 DATA

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 13 Dec 82) pp 317-319

VODYANNIKOV, V. V., POSTOYEV, Yu. K. and TROITSKIY, B. V.,  
Ionosphere Sector, Kazakh SSR

[Abstract] In 1979-1981 the Faraday effect of a signal at 40.008 MHz was measured using the Intercosmos-19 satellite, apogee about 1,000, perigee about 500 km, orbital period 100 minutes, inclination 74°. This article describes disturbances which cause variations in frequency of rotation of the polarization plane of the satellite signal retaining their form for two or three successive orbits. Two types of variations were observed: quasiperiodic variations in the polarization plane and a variation which retained its form for several successive satellite transits, much less frequently observed. This is not the first observation of nonmoving electron concentration formations. Figures 2; references: 5 Russian.  
[150-6508]

## NATURE OF SHORT-PERIOD VARIATIONS OF COSMIC RAYS IN STRATOSPHERE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 29 Jul 83) pp 299-300

BARANNIKOV, Yu. I., BARSUKOV, O. A. and GAVRILOV, P. F., Institute of  
Applied Geophysics; USSR State Committee on Hydrometeorology and  
Environmental Monitoring

[Abstract] Recent articles have reported observing variations in the intensity of cosmic rays in the stratosphere with periods of 100 to 2,000 seconds. A table presents experimental data on variations of cosmic rays in the stratosphere. The similarity of the numerical values of periods of observed variations of cosmic rays in the stratosphere and pulsations in visible diameter of the sun has been reported. However, closer analysis reveals that these variations are attributable to wave movements in the atmosphere at low and middle latitudes, the pulsating leakage of captured radiation induced by resonant oscillations of the magnetic field lines of force in the higher latitudes. The apparent similarity of period with pulsations in the sun's diameter is a random factor. References 13: 11 Russian, 2 Western.  
[150-6508]

DETERMINATION OF VOLUMETRIC COEFFICIENT OF TRUE LIGHT ABSORPTION BY AEROSOL  
BASED ON AIRCRAFT MEASUREMENT OF SPECTRAL FLUX IN CLOUDLESS ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in  
Russian Vol 20, No 4, Apr 84 (manuscript received 22 Dec 82;  
after revision 12 May 83) pp 269-273

CAVRILOVA, L. A., Leningrad State University

[Abstract] An algorithm for computation of the coefficient of true light absorption by atmospheric aerosol is developed. The algorithm is intended to be simple and to require the minimum volume of additional information concerning the state of the atmosphere. The direct and inverse problems were solved in a model to test the algorithm and determine possible sources of error. Spectral fluxes and radiation densities were computed at 1, 2, 4 and 8 km altitude for wavelengths of 0.4 and 0.6  $\mu\text{m}$  in the model. The inverse problem was that of retrieving the absorption coefficient based on the fluxes calculated in the direct problem. Results of experiments carried out in October of 1970 in Central Asia were used to test the method. Figures 3; references: 7 Russian.  
[160-6508]

UDC: 551.521.3:551.576

NUMERICAL MODELING OF RANDOM PROCESSES AND FIELDS BASED ON PALM POINT  
FLUXES IN PROBLEMS OF RADIATION TRANSFER IN CLOUDS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 14 Aug 82;  
after revision 25 Feb 83) pp 274-279

TROYNIKOV, V. S., Computer Center, Siberian Department, USSR Academy of  
Sciences

[Abstract] After discussing the methods used by other authors to produce deterministic models of cloud formation, the author describes a random field model which can include among its parameters empirical data on the stochastic structure of cloud cover with no additional assumptions made concerning the properties of the cloud field. The use of the Monte Carlo method allows solution of the precise transfer equation for such a medium. The author presents a numerical algorithm for this suggested method for the case of homogeneous isotropic fields with univariate Gaussian and univariate gamma distributions. Graphic models illustrate actualizations of the field with Gaussian and gamma distributions. The algorithm is said to be able to construct a broad range of univariate field distributions. The numerical results obtained in calculating the probability of transmission and reflection

of radiation perpendicularly incident on the upper boundary of a cloud layer demonstrate that consideration of the stochastic nature of the process increases the probability of radiation transmission. The numerical results show that when interpreting physical measurements of radiation fields in clouds, consideration of stochastic properties of the medium is important. Figures 4; references: 10 Russian.  
[160-6508]

UDC: 533.95:551.510.535

MECHANISM OF DAMPING OF PLASMA OSCILLATIONS IN INITIAL STAGE OF INJECTION OF ELECTRON BEAMS FROM SPACECRAFT INTO IONOSPHERE IN ACTIVE EXPERIMENTS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 20 Apr 83) pp 205-210

FEDOROV, V. A., Radio Engineering Institute, USSR Academy of Sciences

[Abstract] A study is made of a suggested mechanism of damping of plasma oscillations in the initial stage of injection of electron beams from a spacecraft into the ionosphere and the characteristics are calculated for the parameters used in actual experiments. The study of the interaction of the variable electric field with the plasma electrons creating the neutralization current shows that the suggested mechanism of damping of plasma oscillations in the initial stage of injection of electron beams explains the dynamics of unsteady processes related to changes in the electric potential of the spacecraft and the parameters of the ionospheric plasma. The mechanism of damping of plasma oscillations is confirmed by the results of numerical modeling of the process of neutralization of the charge of a spacecraft in actual experiments. It is possible to pump plasma oscillations in the initial stage of injection of electron beams in active experiments in the ionosphere if the experimental criteria are satisfactorily met. References 6: 5 Russian, 1 Western.  
[150-6508]

UDC: 551.521.32

SIMPLE FORMULA TO ESTIMATE CARBON DIOXIDE GAS EFFECT IN RADIATION BALANCE OF UNDERLYING SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 20, No 4, Apr 84 (manuscript received 22 Dec 82) pp 321-323

ZOLOTOVA, Zh. K. and SHIFRIN, K. S., Institute of Oceanography, USSR Academy of Sciences

[Abstract] A study was made of a number of simple radiation models, selecting those which allow estimation of the role of CO<sub>2</sub> in the radiation



balance of the earth's surface. A simple equation is derived allowing approximate calculation of E. This analytic equation is simple and allows estimation of the direct contribution of carbon dioxide gas to the counter-radiation of the atmosphere, as well as the significance of other factors in the phenomenon. In the 12.5-18.5  $\mu\text{m}$  band the contribution of  $\text{CO}_2$  varies from 35% in very dry air to 8% in very humid air. Counter-radiation is also quite dependent on air temperature, less on moisture content, still less on  $\text{CO}_2$  content. References 7: 6 Russian, 1 Western.  
[160-6508]

UDC: 523.164.42

#### SOLAR WIND DYNAMICS AT SMALL DISTANCES FROM THE SUN

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 27 Apr 83) pp 182-186

LOTOVA, N. A. and BLUMS, D. F., General Physics Institute, USSR Academy of Sciences, Radio Astrophysical Observatory, Latvian Academy of Sciences

[Abstract] A study is made of the medium near the sun at distances of not over 30 solar radii in order to determine the variation of spatial localization of the transition mixed flow area as a function of solar activity level. The dynamics of the medium in the subsonic and transonic areas are studied. It is found that as the solar activity level changes, the location of the area in which subsonic flow is transformed to the supersonic wind also changes. It is concluded that any significant comparison of the theoretical mechanisms of acceleration from the solar plasma with radioastronomical observations can be performed only if the discontinuous, jet structure of the flow of plasma near the sun is considered. The data necessary for this analysis concerning the distribution of solar wind speeds are known from radioastronomical data with sufficient completeness to undertake analysis. Figures 3; references 23: 13 Russian, 10 Western.  
[150-6508]

UDC: 550.388.2

#### DYNAMIC AMPLITUDE, PHASE AND POLARIZATION SPECTRA OF COMBINATION FREQUENCY SIGNALS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 23 Oct 82; after revision 18 Apr 83) pp 196-200

BABICHENKO, A. M., GUSEV, S. A., MITYAKOV, S. N., POLYAKOV, S. V.,  
RAPOPORT, V. O. and SAZONOV, Yu. A., Gor'kiy Radio Physics Institute

[Abstract] Results are presented and discussed from an experiment studying combination frequency signals in which observational data were processed in

real time by means of an Elektronika-60 microcomputer with Kamak standard peripheral devices. The experiment was performed in February, 1982 with periodic heating of the lower ionosphere by means of a short-wave transmitter located near Gor'kiy. The transmitter operated at 5.75 MHz with 100% amplitude modulation at a frequency varying between 1 and 5 KHz at 20 Hz per second. All spectral characteristics of the magnetic field were recorded and processed in real time. Time resolution of the measurement was 7 minutes, frequency resolution 200 Hz. Processing software was written in BASIC. It is found that field polarization is the most informative parameter reflecting the specifics and structure of the ionospheric combined frequency signal source. Figures 3; references 14: 13 Russian, 1 Western.  
[150-6508]

UDC: 550.388.2:550.348.098.436

#### POSSIBLE EFFECTS OF INTERACTION OF ELECTRIC SEISMIC FIELDS WITH THE IONOSPHERE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 8 Jun 82; after revision 27 May 83) pp 217-222

GOKHBERG, M. B., GERSHENZON, N. I., GUFEL'D, I. L., KUSTOV, A. V.,  
LIPEROVSKIY, V. A. and KHUSAMEDDINOV, S. S., Institute of Earth Physics,  
USSR Academy of Sciences

[Abstract] New data are presented on changes in the structure of the ionosphere over the epicenter of an earthquake which has not yet occurred and a possible scenario is suggested for the development of geophysical phenomena resulting from the appearance in the ionosphere of local electric fields of seismic origin. Several new examples are presented on the changes in critical frequency and profiles of electron concentrations in the E and F layers during the periods preceding earthquakes. Specifically, the electron density increases in these layers and a sporadic E layer may be formed. These changes result from excitation of electric fields in the ionosphere. A number of phenomena observed during the period preceding strong earthquakes can be satisfactorily explained by assuming that alternating electric fields arise in the ionosphere at this time. Figures 3; references 15: 9 Russian, 6 Western.  
[150-6508]

## LIDAR MEASUREMENTS OF STRUCTURAL CHARACTERISTICS OF ATMOSPHERIC TURBULENCE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 1 Nov 82; after revision 11 Feb 83)  
pp 314-317

BELEN'KIY, M. S., MAKAROV, A. A., MIRONOV, V. L. and POKASOV, V. V.,  
Institute of Atmospheric Optics, Siberian Division, USSR Academy of Sciences

[Abstract] The lidar method of determining the structural characteristics of fluctuations in the atmospheric refractive index, based on light scattering by natural atmospheric aerosol, greatly expands the possibility of producing timely information on the space-time changes in this parameter. This article presents results from an experimental test of the method over a low-altitude path. The experimental test was performed in August-September of 1979 over paths 30 and 130 m in length using a bistatic system with an He-Ne laser operating at 0.63  $\mu\text{m}$ , 80 mW. The image was scanned for 8 ms, after which the intensity profile was normalized to exclude the influence of fluctuations in the echo signal caused by variations in atmospheric transparency and scattering coefficient. The mean intensity distribution was determined by averaging a series of frames, total averaging time 120-200 s. The asymmetry of the aerosol scattering index was used to increase the signal/noise ratio. The values of the refractive index found by independent optical measurements using several methods are found to agree satisfactorily, indicating that the lidar method can be used to measure atmospheric structural characteristics. Its advantages over existing methods are briefly mentioned. Figures 2; references: 11 Russian.  
[160-6508]

UDC: 523.165

## DIURNAL VARIATION HARMONICS AND SPATIAL CHANGE IN COSMIC RAY FLUX

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 15 Jun 83) pp 297-298

MEL'NIKOV, Yu. P., Rybinsk Institute of Aviation Technology

[Abstract] Conditions of propagation of cosmic rays in interplanetary space are used to obtain more precise equations than previously available for the relative values of diurnal variation harmonics. Equations are derived for the harmonics of diurnal variations assuming that the recorders used for measurement receive radiation in the solar equatorial plane. Experimental data are used for directions close to the solar equatorial plane. The formulas allow more detailed study of the mechanism of the second harmonic of magnetized particles. Harmonics through the fourth are calculated. References 9: 6 Russian, 3 Western.  
[150-6508]

## ELECTRIC FIELD IN PLASMA LAYER OF MAGNETOSPHERE DURING PRELIMINARY SUBSTORM PHASE

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 17 Jan 83) pp 237-241

SERGEYEV, V. A., Leningrad State University, Institute of Physics

[Abstract] Direct and reliable measurement of small electric fields in the hot and rarefied plasma of the tail of the magnetosphere is impossible. The influence of small-scale heterogeneities can, however, be overcome by averaging data over long periods of time if a satellite remains in a single area of the plasma layer. This article discusses analysis of data measured by the IMP-8 satellite on the magnetic field and energetic photon fluxes in the plane of the ecliptic. After verifying that plasma is not accumulated in the central portion of the plasma layer, the authors estimate the maximum possible influence of the desired convection rate component based on measurements of mass fluxes in the plane of the ecliptic. Measurements from the central portion of the layer are most valuable in this work. The assumption of equilibrium status of force tubes within the plasma layer is confirmed. Figures 2; references 13: 7 Russian, 6 Western.  
[150-6508]

## FINE STRUCTURE OF ALFVÉN MASER RADIATION

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 14 Mar 83) pp 242-248

BELYAYEV, P. P., POLYAKOV, S. V., RAPOPORT, V. O. and TRAKHTENGERTS, V. Yu., Gor'kiy Radio Physics Institute

[Abstract] The magnetosphere of the earth can be represented as an Alfvén maser. Various modes of generation have been detected in Alfvén masers. Instability in an Alfvén maser results from cyclotron instability, resulting in turn from transverse anisotropy in captured energetic particles. A theoretical model is constructed of the generation of complex dynamic geomagnetic pulsations by the terrestrial magnetosphere. Quantitative estimates for radiation belt proton energy and precipitating particle energy density are produced. References 7: 6 Russian, 1 Western.  
[150-6508]

## ADDITIONAL POSSIBILITIES OF METHODS OF PARTIAL REFLECTIONS USING A HIGH POWER INSTALLATION

Moscow GEOMAGNETIZM I AFRONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 19 Apr 82) pp 223-227

MARTYNENKO, S. I. and CHERNOGOR, L. F., Khar'kov State University

[Abstract] The purpose of this work is to estimate the possibility of producing additional information on the parameters of the lower ionosphere based on measurements of nonlinear distortions of radio signals using partial reflection devices operating at high power. The partial reflection phenomenon is described in the framework of classical magnetoionic theory. The method can be used to determine the level of disturbance of electron temperatures as well as many other parameters of the lower ionosphere. Good agreement between the experimental and theoretical data is noted. Figures 3; references 9: 8 Russian, 1 Western.

[150-6508]

## REPULSIVE FORCE OF 'MAGNETIC CLOUDS' DURING SOLAR FLARES AND MAGNETOSPHERIC SUBSTORMS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 11 Mar 83) pp 177-181

IVANOV, K. G. and KHARSHILADZE, A. F., Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences

[Abstract] A precise analytic solution is sought to the forces of repulsion for a variety of magnetic clouds, particularly for flattened ellipsoids of revolution with long axis in the direction of the repulsive force. The force acting on a flattened ellipsoid of revolution of this type is analyzed and the solution found for the repulsive force. Application of this solution in estimates of the repulsive force of magnetic clouds in interplanetary space during solar flares and magnetospheric substorms is discussed.

Figure 1; references 22: 8 Russian, 14 Western.

[150-6508]



## LIMITS OF APPLICABILITY OF LONG WAVE THEORY IN STUDIES OF OSCILLATIONS OF n-LAYER FLUID

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 19 Jul 82) pp 329-332

BABIY, M. V., Marine Hydrophysics Institute, Ukrainian Academy of Sciences

[Abstract] In solving problems on the oscillations of an n-layer fluid it is important to know the limits of applicability of the assumptions of the theory of long waves. This article obtains a criterion which can be used to determine whether the vertical acceleration can be ignored in an n-layer fluid. Conditions are determined which must be satisfied by the thickness of the layers and changes of density between them. The equations derived in this article can be applied in studies of the generation and propagation of long waves in n-layer stratified liquids using the approximation of long wave theory. References: 3 Russian.

[160-6508]

## CHARACTERISTIC SCALE OF INNER MIXING LAYERS IN STABLY STRATIFIED ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 13 Sep 82; after revision 24 Feb 83)  
pp 237-241

KURGANSTY, M. V., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] The most accurate estimate of turbulence in a stable stratified natural atmosphere can be obtained by considering the "power" relationships and the rate of expenditure of kinetic energy on turbulent mixing. This article studies the major isothermal status of the atmosphere. The effect of turbulent mixing is one primarily of equalizing the average potential temperature field heterogeneities. The numerical estimate is calculated assuming that turbulence is maintained by the reserves of kinetic energy in the atmosphere generated in general circulation processes. It is found that the equilibrium thickness of internal mixing layers is approximately 16 meters. The results obtained are compared with those yielded by similarity theory for a stratified boundary layer. References 16: 14 Russian,

2 Western,

[160-6508]

## INTERNAL GRAVITY WAVES IN REAL ATMOSPHERE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 22 Oct 82; after revision 9 Feb 83)  
pp 255-261

KAYDALOV, O. V. and SOLOV'YEVA, T. V., Institute of Experimental Meteorology

[Abstract] A study is made of a numerical model of internal gravity waves, a modification of an earlier model produced by the authors to study fluctuations in a spherical rotating atmosphere. The modified model can be used to study internal gravity waves in an atmosphere with temperature and wind stratification close to that observed in the real atmosphere. The work was intended to study resonance properties of the atmosphere with respect to internal gravity waves with phase velocities of over 100 m/s. The results of numerical modeling also allow estimation of the power of the assumed sources of the resonance waves. Figures 3; references 11: 10 Russian, 1 Western.

[160-6508]

UDC: 551.501.724:528.061.2

## INFLUENCE OF REFRACTION EFFECTS ON INFORMATIVENESS OF BISTATIC ACOUSTICAL ATMOSPHERIC SOUNDING SYSTEMS

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 18 Oct 82; after revision 29 Apr 83)  
pp 262-268

BOGUSHEVICH, A. Ya. and KRASNENKO, N. P., USSR Academy of Sciences, Siberian Division, Institute of Atmospheric Optics

[Abstract] The influence of regular refraction on the angle and time of arrival of a signal is studied for a bistatic sounding system in order to produce equations relating these parameters to wind speed and temperature profiles. The method of geometric acoustics is used, since the wavelength of the sound radiation is short in comparison to the characteristic dimensions of regular atmospheric heterogeneities. Meteorological fields are assumed to be steady and horizontally homogeneous in the scale of measurements characteristic for acoustic soundings. It is found that measurement of the angle and time of arrival of a signal in bistatic sounding can be used to obtain information on the profiles of  $V_x$ ,  $V_y$  and  $T$ . Equations are presented which can in the first approximation represent refraction effects which, if ignored, might yield an unacceptably large error. Figure 1; references 12:

5 Russian, 7 Western.

[160-6508]

## LONG-DISTANCE PROPAGATION OF INFRASOUND IN ATMOSPHERE NEAR EARTH'S SURFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 25 Nov 82) pp 309-311

BUSH, G. A., GRACHEV, A. I., KULICHKOV, S. N., MATVEYEV, A. K.,  
MORDUKHOVICH, M. I. and OTREZOV, A. I., Institute of Atmospheric Physics,  
USSR Academy of Sciences

[Abstract] An experimental explosion with an energy of  $1.1 \cdot 10^{12}$  J, a part of an experimental program for modeling magnetic-atmospheric coupling during seismic phenomena, was audible at a distance of up to 200 km from the source. This long-distance propagation of sound resulted from formation of an acoustical waveguide due to a temperature inversion. Since the possibility of this type of long-distance sound propagation at low altitudes had not previously been experimentally confirmed, this work presents some results of observations of long-distance sound propagation within an acoustical waveguide in the boundary layer next to the earth during the experimental magnetospheric modeling program. The blast was set off at 8:31 local time in a plains area in Alma-Ata Oblast. Wave modes which can most effectively propagate through the natural waveguide are calculated. Attenuation is found to vary approximately inversely with distance as in experimental waveguides. Figures 4; references 7: 5 Russian, 2 Western.

[160-6508]

## STUDY OF LOW-FREQUENCY SOUND WITH POINT SOURCE IN STREAM WITH SHEAR

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 25 Nov 82) pp 312-314

GONCHAROV, V. P., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] A study is presented of the three-dimensional structure of acoustical atmospheric oscillations produced by a point radiator when wind stratification typical for the boundary layer is present. For sufficiently low-frequency radiators, such that geometric acoustics cannot be used, the horizontal field structure in the plane of the source can be calculated. In particular the rate of attenuation of field amplitude at very great distances can be computed in terms of the external scale of the problem. The problem is solved assuming a barotropic medium of homogeneous density over a horizontal side surface and a point source of radiation.

References: 5 Russian.

[160-6508]

## ANALYSIS OF IONIZATION SOURCES IN D REGION BASED ON THEORETICAL MODELS

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 6 Jan 83) pp 187-190

VLASOV, M. N. and MEDVEDEV, V. V., Institute of Applied Geophysics;  
USSR State Committee on Hydrometeorology and Environmental Monitoring;  
Kaliningrad State University

[Abstract] An attempt is made to analyze sources of ionization in the D region and explain their comparative significance based on a numerical theoretical model, in which the space-time distribution of the neutral and ionic composition of the mesosphere and lower thermosphere are calculated on the basis of a system of equations for a weakly ionized plasma in a one-dimensional approximation. Results of calculations performed for conditions of moderate solar activity at geographic latitude 45°N and quiet geomagnetic conditions are analyzed. Analysis showed that the relative role of ionization sources in the D region depends quite strongly on season and time of day. During the winter practically all ionization in the D region is determined by ionization of nitrogen oxide by  $L_{\alpha}$  radiation; in the summer around noon ionization of oscillation- and electron-excited oxygen molecules is as important as ionization of nitrogen oxide; during the morning and evening in the summer an intermediate situation prevails. Figures 2; references 10: 5 Russian, 5 Western.  
[150-6508]

## MEDIUM- AND LARGE-SCALE WAVE DISTURBANCES AND HETEROGENEITIES OF ELECTRON CONCENTRATION IN OUTER IONOSPHERE IN MIDDLE AND LOW LATITUDES

Moscow GEOMAGNETIZM I AERONOMIYA in Russian Vol 24, No 2, Mar-Apr 84  
(manuscript received 11 Apr 83) pp 191-195

FATKULLIN, M. N., SOLODOVNIKOV, G. K., LEGEN'KA, A. D., and  
DRUKARENKO, S. P., Institute of Terrestrial Magnetism, Ionosphere and Radio  
Wave Propagation, USSR Academy of Sciences

[Abstract] Results are presented from studies of medium- and large-scale heterogeneities in electron concentration  $m_e$  for typical heliophysical and geophysical situations by means of capturing a large interval of altitudes in the outer ionosphere (over 3,000 km altitude) with sharply varying physical conditions and analysis of high solar activity conditions in the middle and low latitudes. Data from the Alouette-2 satellite were used. The method of determining heterogeneities was discussed in previous works and is omitted here. Energy spectra and mutual correlation of fluctuations of  $m_e$  at different altitudes are studied. In a previous work

the excitation of electron concentration heterogeneities and wave movements of medium and large scale in the outer ionosphere were related to the propagation of internal gravity waves and ionosonic oscillations. During periods of low solar activity the former of these mechanisms is effective at altitudes of 450 km and less, the latter at 550 to 1,000 km altitude. During high solar activity periods, the height of the transition from predominance of the first mechanism to the second rises due to the rise in the upper neutral atmosphere, resulting in an increase in the altitude of  $O^+ \rightarrow H^+$  transitions. Figures 3; references 10: 8 Russian, 2 Western. [150-6508]

UDC: 551.521.32:551.576

#### MODELING INFLUENCE OF THREE LAYER CLOUD COVER ON OUTGOING THERMAL RADIATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian Vol 20, No 4, Apr 84 (manuscript received 2 Sep 82; after revision 11 May 83) pp 242-249

GRACHEVA, I. M., MOKHOV, I. I. and PETUKHOV, V. K., Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] The structure of the outgoing thermal radiation flux of a system consisting of an atmosphere with three layers of cloud cover and an underlying surface is calculated and the sensitivity of the radiation flux to changes in the cloud cover is estimated. The model of the outgoing radiation flux with three cloud layers is based on the use of an integral transmission function for thermal radiation. The major optically active components of the model atmosphere in the thermal range of the spectrum within the troposphere are assumed to be water vapor, carbon dioxide and aerosol. The stratospheric layer is considered to be in radiative equilibrium with the troposphere. Aerosol is not considered in this study. The results of the calculations performed are expressed as the variation in the outgoing flux and its sensitivity as functions of changes in altitude of the upper boundary of the effective cloud layer located at the altitude of each of the three cloud layers actually present. Models of the outgoing radiation flux with multiple cloud layers are closer to reality than models based on a single effective cloud layer. Great differences in flux sensitivity obtained with different empirical data concerning the cloud cover require empirical studies of the mutual restructuring of clouds at various levels on a global scale. Figures 4; references 14: 8 Russian, 6 Western. [160-6508]



ACTUAL ALTITUDES OF RADIOACOUSTIC SOUNDING IN DECIMETER WAVELENGTH BAND

Moscow IZVESTIYA AKADEMII NAUK SSSR: FIZIKA ATMOSFERY I OKEANA in Russian  
Vol 20, No 4, Apr 84 (manuscript received 13 Dec 82) pp 250-254

BELYAVSKAYA, V. D., KALLISTRATOVA, M. A., KARYUKIN, G. A. and PETENKO, I. V.,  
Institute of Atmospheric Physics, USSR Academy of Sciences

[Abstract] An earlier work by one of these authors produced an expression for the signal-to-noise ratio achieved in radioacoustic soundings allowing estimation of the maximum sounding altitude under actual conditions, considering mean wind speed and antenna location. In this article further analysis of this equation shows that under actual characteristic conditions the primary contribution to decreasing the useful signal and thus decreasing  $H_{\max}$  is that of displacement of the center of the spot of mirror-reflected radiation from the aperture of the receiving antenna, disrupting the conditions of synphase addition of scattered waves in the reception area. By assigning the minimum necessary signal-to-noise ratio for adequate signal processing, the equation can be used to calculate the theoretical variation of  $H_{\max}$  as a function of transverse wind speed for a specific radiosounding system. Theoretical results obtained in this manner are compared with experimental data obtained with a decimeter waveband system, yielding good results. Figures 3; references 6: 4 Russian, 2 Western.

[160-6508]

## ARCTIC AND ANTARCTIC RESEARCH

### STATION ON LEDNIK VAVILOV CONDUCTS RESEARCH

Leningrad LENINGRADSKAYA PRAVDA in Russian 19 Aug 84 p 4

[Article by N. Osipov: "On the Icy Dome"]

[Text] At the summit of the glacial dome of Vavilov, which is on the island October Revolution in Severnaya Zemlya, the only arctic covered-glacial station in the USSR is operating successfully. It is located at an altitude of 650 meters above sea level about 1,000 kilometers from the North Pole.

A small scientific town has grown up on the dome: living quarters for those spending the winter there, rooms for scientific laboratories, a diesel electric power station, and permanently installed and mobile drilling installations. Polar pilots of aircraft and helicopters based at the coastal stations are always ready to carry out any assignment of the scientists.

In recent years, more than 300 specialists have conducted scientific research here. Glaciologists measured the thickness of the glacier and made a detailed map of its bed at a depth of 600 to 640 meters. Cores have been taken from the interior of the ice, and they are being studied in laboratories in Leningrad and Tallinn. For the first time, an analysis of the data gave a picture of the climatic changes that have occurred in this region of the Arctic.

The finding of teeth and tusks of mammoths has shown that there were no glaciers 11,000 years ago on the archipelago of Severnaya Zemlya and that it was green with vegetation. Radiocarbon analysis was used to determine the age of the remains of the ancient animals.

9746

CSO: 1865/61

## DEVELOPMENT OF RADAR TO MEASURE SEA ICE MERITS PRIZE NOMINATION

Moscow IZVESTIYA in Russian 1 Sep 84 p 3

[Article by Yu. Kobzarev, academician, Hero of Socialist Labor]

[Excerpt] Research of the Riga Institute of Civil Aviation Engineers has helped to create a new field of radar technology--subsurface radar. This research began with sea ice, for which field experiments were conducted to determine the optimum shape of the sounding signal. An original method was proposed which makes it possible to overcome the contradiction between the permissible value of radio-wave attenuation in sea ice and the possibility of distinguishing the [top and bottom] surfaces of ice cover separately.

Onboard aircraft apparatus which was developed has begun to be used extensively for ice reconnaissance in various regions of the Arctic and on inland bodies of water of our country. A great contribution to the solution of this problem was made by specialists of the Ministry of the Radio Industry, who worked out the schematic concept for the method of receiving and processing signals, and developed an aircraft instrument for remote measurement of the thickness of sea ice. This instrument, which is the first of its kind in world practice, was developed jointly with the Riga institute. Together with specialists of the State Committee on Hydrometeorology and Monitoring of the Natural Environment and the Ministry of the Merchant Fleet, the specialists of the Ministry of the Radio Industry helped with the introduction of the new remote measuring method into ice reconnaissance and aerial surveying for ice-measurement purposes.

A whole set of instruments has been developed, particularly instruments for determining the thickness of peat beds, the depth of frozen soils, etc.

The work on the topic "Development of a Radar Method for Remote Measurement of the Thickness of Sea and Fresh-Water Ice, and Development and Introduction of Onboard Measuring Instruments" is a major scientific and technical achievement and deserves to be awarded the 1984 USSR State Prize.

FTD/SNAP

CSO: 1865/56

CARGO VESSELS FOR SHIPPING TO ARCTIC POINTS WITHOUT PORT FACILITIES

Kiev RABOCHAYA GAZETA in Russian 12 Sep 84 p 1

[Article by A. Yaitskiy, editor of the plant newspaper "Sudostroitel'" (Kherson)]

[Excerpt] The construction of autonomous supply ships has begun on the slips of the Kherson Shipbuilding Production Association. These new-type vessels will deliver cargo to points on the shores of the Arctic basin.

The supply vessels will be capable of delivering cargo to any point on the Arctic coast. They will be unloaded on the water with the aid of helicopters. The fact that cargo items will go to the Arctic in containers and packages will facilitate all handling operations.

FTD/SNAP

CSO: 1865/56

## SCIENTISTS FROM MANY NATIONS CONDUCT ANTARCTIC RESEARCH

Moscow PRAVDA in Russian 17 Aug 84 p 6

[Article by V. Bardin, candidate of geographic sciences]

[Excerpt] The participants in the seasonal work are to carry out some prospecting in the mountains and on the glaciers of Antarctica and in the seas of the southern ocean. Geologists and geophysicists will carry out new research in the region of the shelf of the Weddell Sea, on the Antarctic Peninsula and in the Prince Charles Mountains. From the "Soyuz" field base, geographers will continue to study unique lakes located in this region.

A good many scientific projects are being carried out in the Antarctic through the combined efforts of a number of countries. An example is the International Antarctic Glaciological Project, in the implementation of which scientists from the USSR, United States, Australia, Great Britain and France are participating. Work on this project is also included in the plans for the 30th SAE [Soviet Antarctic Expedition]. It is planned to have scientists from the GDR, Cuba, United States, France...participate in the work of the new expedition.

Also included in the plans for the 30th SAE is research in specific applied questions, in particular in the work to create ice moorings and takeoff and landing strips on the ice. The coming expedition is to construct a wardroom at Russkaya Station, known as the "wind pole." It should be unnecessary to say that this building must be planned to be especially solid.

9746

CSO: 1865/58



## WEDDELL POLYNIA AS RESULT OF HYDROPHYSICAL PROCESSES IN WEDDELL CIRCULATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 276, No 5, Jun 84

BAGRYANTSEV, N. V. and SARUKHANYAN, E. I., Arctic and Antarctic Scientific Research Institute, Leningrad

[Abstract] During the winters of 1974-1976, in the inner part of the Weddell Circulation, against the background of a continuous ice cover, there was an extensive region of an anomalously small concentration of ice or even open water, given the name Weddell Polynia. It could not be detected in subsequent years. Since the reasons for its appearance were obscure, an effort was made to clarify the problem. It was revealed that one of the necessary conditions for the initialization of the polynia was the movement of a warm topographic eddy into what might be called the preparation region. It was possible to estimate the heat flow into the upper layer under these conditions on the assumption that the intensity of the Weddell Warm Countercurrent was sufficiently great that a warm eddy would be detached from a bottom rise and carried into the preparation region. Assuming a horizontal dimension of the warm eddy equal to 300 km, it was found that during the year the eddy would move a distance equal to its diameter. This agrees with the fact that during the year the mean position of the polynia was not observed to the west of 20°W. With the onset of winter cooling the density of the mixed layer will increase. At some moment in time, when the temperature of the upper layer tends to the freezing point, the stability at the interface attains a low value and then a small disturbance will be sufficient for the onset of convection, the best conditions prevailing in the warm eddy. The scale of the disturbances will be determined by the deformation radius. It can be postulated that a regime of spatially intermittent convection in the form of "chimneys" developed. It appears that the heat flow into the upper layer in a warm topographic eddy due to intense winter convection in the form of "chimneys" during the five winter months could be adequate for maintaining the temperature of the upper layer above the freezing point, thereby impeding the formation of ice and favoring polynia formation. Figures 2; references 13: 1 Russian, 12 Western.

[239-5303]

## HISTORY AND PROGNOSIS OF CHANGES IN ANTARCTIC ICE COVER

Moscow VESTNIK MOSKOVSKOGO UNIVERSITETA, SERIYA 5: GEOGRAFIYA in Russian  
No 3, May-Jun 84 (manuscript received 24 Jun 83) pp 10-17

MYAGKOV, S. M.

[Abstract] The basic characteristics of the Antarctic ice cover are described. The changes in the ocean level and periods in the history of the Antarctic ice cover are diagrammed. The history of the Antarctic ice cover apparently started some 38 million years ago when the Antarctic circumpolar current was closed. The first, rapid stage of development of the ice cover ended 30 to 25 million years ago. Subsequent stages include the second Late Oligocene and early Miocene stage of slow growth, the third stage of development associated with a drop in sea level by 400 m some 8 to 7 million years ago and fourth, the stage of maximum Antarctic glaciation from 8-7 to 2.5-2 million years ago, then finally the fifth stage of significant reduction in ice cover associated with the rise in ocean level to higher than the present level about 2 million years ago and subsequent fluctuations in ice cover in association with glacioeustatic fluctuations in sea level. It is predicted that the technogenic rise in mean temperature will not cause significant changes in Antarctic ice cover. References 19: 11 Russian, 8 Western.  
[174-6508]

## SPECIFICS OF EVOLUTION OF CYCLONIC RING IN ANTARCTICA

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 275, No 4, Apr 84  
(manuscript received 21 Jul 83) pp 1012-1015

IVANOV, Yu. A., KRASNOPEVTSEV, A. Yu., MOROZOV, Ye. G., SHADRIN, I. F.,  
and SHCHERBININ, A. D., Institute of Oceanography imeni P. P. Shirshov,  
USSR Academy of Sciences, Moscow

[Abstract] A study is made of the specifics of evolution of eddies in the interfrontal zone in the example of a clearly expressed frontal cyclone. An analysis of measurements demonstrates that intensification of the frontal eddy is among the first stages of evolution. Measurements were performed in the winter of 1982-1983 aboard the research vessel "Dmitriy Mendeleev" near New Zealand to study synoptic disturbances near the south polar front. Three hydrophysical surveys were performed: one reconnaissance survey and two with higher spatial resolution (20 nautical miles). For the first time, intensification of cold rings was observed in this ocean. This effect

creates significant heterogeneities in the distribution of the flow, temperature, salinity and other fields, significantly greater than their climatic values. This indicates the leading role of frontal eddies in the meridional exchange of properties in the interfrontal zone of the southern ocean. Figures 4; references: 4 Russian.  
[156-6508]

CSO: 1865

- END -

**END OF**

**FICHE**

**DATE FILMED**

DEC 84